MASTER

MATEMATHICAL FINANCE

MASTER'S FINAL WORK

DISSERTATION

PURCHARSING POWER PARITY THEORY IN THE CONTEXT OF THE EURO CURRENCY

AFONSO SALGADO PORTO COELHO

OCTOBER - 2017

MASTER

MATEMATHICAL FINANCE

MASTER'S FINAL WORK

DISSERTATION

PURCHARCING POWER PARITY THEORY IN THE CONTEXT OF THE EURO CURRENCY

AFONSO SALGADO PORTO COELHO

SUPERVISIORS:

TIAGO MIGUEL PROENÇA CARDÃO PITO

OCTOBER - 2017

Abstract

This thesis focuses on the purchasing power parity (PPP) theory in the context of the euro from 1999 to 2016. PPP suggests a specific association between exchange, inflation and interest rates. The euro has eliminated exchange rates among participating countries. We inquire whether the elimination of the exchange rate could be reflected, similar to the inflation and interest rates of euro-area countries, consistent with PPP.

The study has followed a panel of twelve countries from the introduction of the euro in 1999 until 2016. These countries are Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain.

The findings show that after an initial period of similarity, and despite the elimination of exchange rates among these countries, inflation and especially country-level interest rates have exhibited a great degree of divergence. Therefore, these results may question the validity of the relationships PPP predicts in the context of the euro. Although the exchange rate between these countries remained the same, inflation and interest rates did not.

Keywords: Exchange rate, interest rate, inflation rate, stationarity, cointegration, unit roots, purchasing power parity

LISBON
SCHOOL OF
ECONOMICS &
MANAGEMENT
UNIVERSIDADE DE LISBOA

Acknowledgement

I would like to thank my supervisor Tiago Cardão-Pito for his support, guidance and suggestions on the process to make the thesis. I would like to describe my gratitude to my supervisor. I am also grateful to Rui Constantino for his helpful advisement.

Table of Contents

1. Introduction

The purchasing power parity (PPP) theory provides a benchmark for policy makers and market agents. This theory predicts a relation among the exchange rates, interest rates and inflation rates of different countries. If two countries do not have the same currency and if when converting currencies the price of a basket of goods is not the same, the price difference must be compensated and explained by two variables—namely, inflation and interest rates.

However, in the context of the European Union, nineteen countries have adopted the same currency and have therefore eliminated the exchange rate among them. If the prices of goods and services in the euro area ar e not the same, could this be explained by long-term relationships between exchange, inflation and interest rates? In past research, and better described in the literature review, mixed evidence has been found with regard to PPP. In this thesis, PPP is tested along different mathematical and quantitative methodologies such as average, variance, cointegration at stationarity levels and fractional cointegration (Diebold, Husted and Rush 1991, Wu and Crato 1995, Cheung and Lai 1993). This thesis is organized as follows. The second chapter reviews scientific literature regarding PPP theory**.** The third chapter presents the research question, data and methodology**.** The fourth chapter presents the findings**.** The fifth chapter discusses the results obtained in chapter four, and the sixth chapter concludes the thesis.

2. Literature review

This section presents a review of the literature about PPP, a theory that suggests a relation among exchange, interest and inflation rates. Furthermore, this section introduces the context of the euro, through which the exchange rate has been eliminated among the countries that have adopted it.

2.1. Purchasing power parity theory: The relation among inflation, exchange and interest rates

2.1.1 Introduction

The exchange rate is the price of one country's currency in terms of another country's currency. This rate could be affected by factors such as pressures regarding demand and supply and the prices of other assets, such as bonds or real estate. Exchange rates can face high volatility. In the short term, interventions from central banks are rationalized to reduce excessive variability in exchange rate movements resulting from the variability of market expectations. However, according to PPP, in the long term, movements of exchange rates tend towards a relationship among currencies. That is, the same parity among dollars, yen or euros would purchase the same amount of goods at home or abroad. Thus, a country with a relatively rapid inflation rate will have its currency decline in value relative to the currencies of countries with slower inflation rates. Since exchange rate depreciation usually precedes changes in domestic prices, it can appear to cause inflation (Shapiro 1991).

If a country's economy and processes are relatively stable, then speculating is expected to smooth the movements of the exchange rate. As expectations can change greatly on a day-to-day basis, the governments and economies of those countries will suffer an impact, meaning that expectations will not be strongly held (Friedman, Milton; and Robert V. Roosa 1977).

In a two-country world, if the first country's inflation rate surpasses the second country's inflation rate, the first's currency will weaken. Hence, there will be a depreciation of the home currency (HC) if the country's inflation/interest rate is higher than the foreign country's inflation/interest rate.

By itself, PPP is a theory about the relationships between endogenous variables. It is a model of constant equilibrium in exchange rates with a long-term association. The concept of PPP can be described by its three main features: the law of one price (LOP), absolute PPP and relative PPP.

2.1.2 Law of one price (LOP)

The LOP holds that the price of an identical good that is internationally traded should be same when the price is converted to different currencies. Otherwise, a process of arbitrage would occur. People could buy the good from locations where the price is low and sell the good to locations where the price is higher, thereby earning riskless profit (i.e. arbitrage). This arbitrage would eliminate any differences between the good's price when external costs are considered negligible. Based on the laws of supply and demand relative to price, any price differential would dissipate over time. Eventually, there would no longer be any potential for arbitrage. The equation of the LOP is following:

$$S = \mathrm{A}\frac{\mathrm{P}}{\mathrm{P}^{*}}$$

Where S is the nominal spot exchange rate;

P and P^* are the prices for an identical good in the domestic and foreign country, respectively; and

A is an arbitrary constant (Kai Zhang, 2012).

2.1.3 Absolute PPP

Instead of identifying prices for goods, as is done through the LOP, absolute PPP applies a general price index. For example, identical comparable goods are probably not in the basket of goods. In the relationship between the LOP and absolute PPP, it is interesting to observe the inflation rate, as it indicates the fluctuation of the prices of identical goods over a given period, which means that absolute PPP expands the bands of PPP in order to explain a more general situation (Kai Zhang, 2012).

Absolute PPP can be written using the ratio:

$$S = \frac{P_d}{P_f}$$

Where P_d is the domestic price and

P_f is the foreign price

2.1.4 Relative PPP

In agreement with Shapiro (1991) Similar to absolute PPP, relative PPP investigates the movements of exchange rates and prices. Relative PPP, however, examines the relative changes in price levels between two countries and maintains that exchange rates will change to compensate for inflation differentials. If one country experiences higher inflation than another does, the exchange rate for the first country's currency will decline. Absolute PPP implies relative PPP if the same basket of goods is used in the comparisons to represent absolute PPP.

Relative PPP describes the differences in inflation rates between two countries. It allows for deviations from parity. The fall in value of the dollar relative to the euro could suggest the euro would be a better choice as a base currency in PPP calculations. Moreover, relative PPP is linked with inflation, exchange and interest rates. The logarithmic relationship between exchange rates and price indices can be written as:

$$\ln(S) = \ln\left(A\frac{P_d}{P_f}\right) = \alpha + \ln(P_d) - \ln(P_f) + \varepsilon$$

Where P_d is the domestic price;

P_f is the foreign price;

α is a constant deviation; and

ε is the stochastic stationary deviation.

This means that relative PPP is an improved version of the original PPP theory, but is more suitable for PPP empirical analysis (Zhang, 2012).

According to PPP, if expected real returns were higher in one currency than in another, capital would flow from the second currency to the first. By delaying fundamental exchange rate adjustments, government intervention can reduce the uncertainty caused by disruptive exchange rate changes for exporters and importers. Deflation is a general decrease in prices in an economy. Hence, if there is an excess supply of goods but not enough money, deflation may happen, whereas disinflation shows the transformation of the inflation rate over time. Therefore, one way to strengthen a currency's value is through disinflation to end the threat of devaluation (Shapiro, 1991; Friedman, Milton; and Robert Roosa, 1977).

2.1.5 Further considerations

Economic forecasting is generally produced through models. Therefore, to try to forecast economic data, one needs a set of relationships between variables. Generally, at least one of these variables is to be forecasted. However, the potential for periodic government intervention makes currency forecasting quite difficult (Shapiro, 1991; Dufey, Gunter, and Ian Giddy, 1978).

According to Bordo (1981), the rise in domestic price levels made US exports more expensive, creating a deficit in the US's balance of payments. The US trade deficit was financed by gold exports to its trading partners, reducing the monetary gold stock in the US. If we compare two long-term equilibria that differ only with respect to monetary supply, relative PPP appears to hold up. In a similar manner, this theory argues that a negative relationship between the exchange rate and the interest rate can be justified by portfolio reallocations as a result of changes in the interest rate. As a country's interest rate increases, its interest-bearing assets become more attractive, all else being equal (Engel, 2016).

This mechanism is present in equilibrating expected asset returns, as found in the uncovered interest rate parity condition. This indicates a negative relationship between the domestic interest rate and the spot exchange rate, holding the foreign interest rate and the expected future exchange rate as constant. On the other hand, a positive relationship between interest rates and exchange rates can result from the effect of exchange rates on aggregate demand. A higher exchange rate leads to an increase to a country's trade balance (Shapiro, 1991).

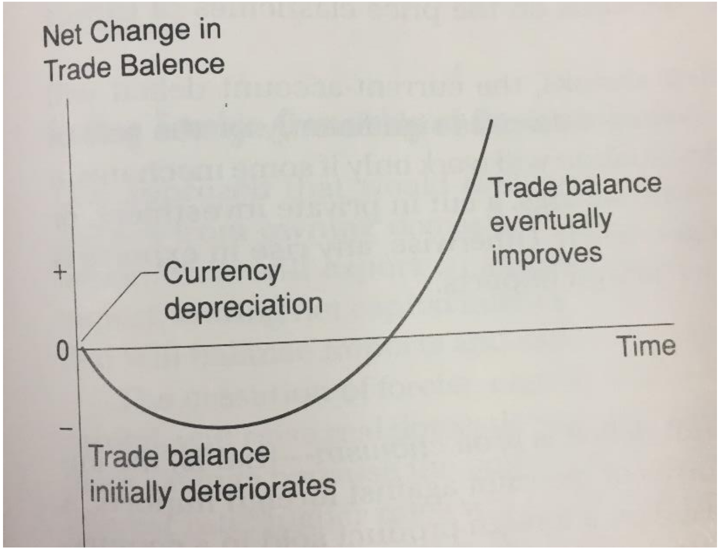

Fig. 1. The Theoretical J-Curve adapted from Shapiro (1991).

In Cavallo and Ribba (2014), the presence of different stationary variables, the convergence of national inflation rates and the euro-area inflation rate require the inflation differential to be a stationary variable. More precisely, a systemic, desirable property for a currency area is that the different national rates would gravitate around the European Monetary Union (EMU) average inflation.

PPP states that exchange-adjusted price levels should be identical worldwide. Hence, a unit of the HC should have the same purchasing power around the world. This idea is linked to the LOP, but it must be reformulated in such a way that accounts for transportation and transaction costs between countries, since they are positive. Arbitrage may be too costly because of transportation costs, and the prices of the item could change during transportation. Such price changes could lead to an absence of an inflation differential, and if the local government were to intervene, it could consequently cause the disequilibrium of the exchange rate. These factors explain why the PPP might not hold (Karl Persson, 2008).

2.2. Empirical results regarding the relation among interest, exchange and inflation rates

2.2.1 Empirical findings about PPP theory

According to Ida Bache (2006), there are two broad categories of tests with respect to PPP. The first group tries to test the LOP by comparing prices of individual goods across countries. This test was used on a case study made by Haskel and Wolf (2001), who found that deviations from the LOP are large are persistent. Moreover, those deviations reflect changes in nominal exchange rates. The second group tests relative PPP by observing if the real exchange rate is susceptible to converging on a constant value as time progresses (i.e. tests of unit roots in the real exchange rate).

Nonetheless, the earliest test, which relates to a study made by Frenkel (1981) rejected the PPP hypothesis, except in hyperinflating economies, as the failures of exchange rate models may be attributed to assume incorrectly that PPP is accurate. It is hard to measure the relationship between nominal exchange rate and relative prices, even if the price indices are calculated with strict standards. The results suggest that PPP does not hold continuously (Taylor, 1995).

Rogoff (1996) summarised the famous PPP puzzle as follows: if the exchange rate can be so volatile in the short term, why does it take such a long time for it to converge on the exchange rate predicted by PPP? A number of empirical studies have documented that exchange rate behaviour can be well captured by the smooth transition autoregressive (STAR) model from Granger and Teräsvlrta (1993).

Cumby (1997) studied Big Mac parity, which is based on PPP, to investigate exchange rates across different currencies and how they should be adapted in order to have identical costs for a specific basket of goods. Furthermore, he argues that if adjustments towards parity take place through exchange rates, then Big Mac parity may be helpful in forecasting exchange rate changes. The focus of the study was based on Rogoff's dilemma: reconciling large, short-term deviations from parity with slow deviations back to parity.

In a recent paper, Altissimo, Benigno and Palenzuela (2011) study the underlying factors of inflation differentials in a currency area. In an empirical sense, they find two main results: persistent inflation differentials affect the euro area and the different responses of Eurozone countries to euro-area shocks play a pre-eminent role in explaining the evolution of the inflation differentials.

2.2.2. Why is purchasing power parity considered empirically imperfect?

Taylor (2000) points out that several studies support the relative PPP hypothesis, since the deviations from PPP are extremely volatile and large in the short term. Most findings lean in the direction of Rogoff's (1996), since the deviations in PPP seem to disappear. The short-term volatility of real exchange rates can be reconciled with the slow rate, as short-term exchange rate volatility points to financial and monetary shocks.

What could be the flaws of PPP? As mentioned previously, there are transportation costs, tariffs and taxes to be paid as well as external information and technology. This border effect is illustrated by Rogers and Jenkins (1995), who revealed that identical goods at different locations are different economic objects and that the specifications of each location are essential to know. The variations in the prices for similar goods across borders appear to be far more significant in explaining real exchange rates than the movements in the relative prices of different goods within a country's borders are. Engel and Rogers (1996) conclude that when markets are segmented, price discrimination can occur.

Nominal exchange rates can fluctuate without influencing each other, resulting in a wedge between the prices for domestic and foreign goods. Eventually, this leads to imperfect competition in the market, because better conditions are required for foreign companies to invest in another country for the balance between demand and supply to be near the conditions of equilibrium.

2.3. Exchange, interest and inflation rates after the euro

Exchange rate movements might affect inflation in the euro area. The exchange rate can influence euro-area inflation both directly via the price of imported final consumer goods and indirectly via the price of imported intermediate goods used in euro-area domestic production.

In general, fluctuations of or adjustments to price levels cannot keep pace with the change of economic structure, which will shock the exchange rate. Therefore, PPP cannot be an accurate predictor of real exchange rate, since the international movements caused by economic structural change influence the exchange rate.

Devaluation, in its turn, calls for inflation. In fact, as foreign firms tend to lose market share in the euro area following a depreciation of the euro, they must keep their prices as stable as possible. The euro's depreciation translates into higher production costs due to more expensive imported inputs with an inflationary impact on domestic consumer prices.

The European Union is built on the idea of a single market defined as an area without frontiers in which the free movement of goods, persons, services and capital is ensured. However, this policy leaves the rest of the world at a disadvantage in relation to these conditions, as the economic conditions and politics of European countries are made in a way where the balance of exports and imports outside of Europe is more restrictive than they are from Europe to other countries.

Cardão-Pito (2017) notes that rating agencies' failures are consistent with Reinhart and Rogoff's (2009) claim that sovereign ratings are not good indicators of the likelihood of banking and/or sovereign crises. These countries' current accounts showed yearly deficits, with imports being systematically higher than exports (Lane, 2012; Mirdala, 2015). At the beginning of the euro currency system, the Greek and Italian banking sectors did not show any signs of bubbles. Eventually, banks were pushed into crisis by systematically funding government budget deficits.

The two basic features of the European monetary system (EMS) were the exchange rate mechanism (ERM) and the European currency unit (ECU). The ECU was a composite currency through which all member states' currencies were represented in different quantities.

As Emerson et al. (1992) note, the independence and autonomy of the European Central Bank is, in a way, a structure in which a stable and credible monetary regime requires an independent central bank to guarantee price stability.

Until 2008, the European economy did not have many risks, as the Monetary Union still worked, although it had its limitations. The Central Bank defined the interest rates both in the short term and in the long term. The crisis came to reveal that since the banks are not the same the risks and economies are not the same, and a bank crisis could result in a sovereign crisis where the government has to intervene. Usually in this situation, there would be a transfer of risk from the financial sector to the public sector.

In 2005, Ludger Linneman performed a study, in which he stated that a higher real interest rate with a balanced government budget commands a higher tax rate since it implies higher interest payments on the existing stock of debt and because reduced demand diminishes the tax base. He made the following three points:

(i) the inflation response to higher interest rates is increasing;
(ii) the consumption response is decreasing in the steady-state debt-to-output ratio; and

(iii) for standard parameters, with debt-to-output levels observed in many European countries, a nominal interest rate increase can even increase inflation.

Forward-looking variables, including market expectations of macroeconomic indicators, are likely to contain relevant information about future movements in the yield curve. Core inflation has been generally considered the appropriate operational target. This measure has been stable and has been a good indicator of underlying (long-term) inflation, particularly in developed economies. By expressing aggregate inflation as a weighted average of the inflations of these two sectors and varying the weight of flexible-price inflation, we consider the inflation measure to be a policy variable.

The fundamental equilibrium exchange rate is defined as the real effective exchange rate value that is compatible with macroeconomic equilibrium. The fundamental equilibrium exchange rate is sometimes referred to as a way that estimates the real effective exchange rate equilibrium. fundamental equilibrium exchange rate (FEER) shows that the value of the exchange rate that is the result of current account assets or deficits, which in turn is appropriate for the long-term structural inflow of the capital or economy outflow, assumes that the country does not have restrictions to trade freely and is trying to attain internal balance. FEER focuses on a theory of exchange rate determination that predicts the future evolution of the exchange rate, as it calculates the medium-term real effective value of a currency in order to assess the current value of the exchange rate. In the behavioural equilibrium exchange rate (BEER), the previous concept is absent, as the relevant notion of equilibrium is the value given by an appropriate set of explanatory variables.

FEER internal balance is identified as the level of output consistent with both full employment and a low, sustainable rate of inflation. The external balance is characterised by the flow of resources between countries. This model uses the core of the macroeconomic balance approach, as this is the identity equating the current account (CA) to the negative of the capital account (KA) ($CA = -KA$). The equilibrium relationship between the current and capital accounts is given by the equation:

$$CA = b0 + b1q + b2\bar{y}d + b3\bar{y}f = -\mathrm{KA}$$

Where q is the real effective exchange rate;

$\bar{y}d$ is the function of home demand;

$\bar{y}f$ is the function of foreign aggregate output; and

$b1 < 0$, $b2 < 0$ and $b3 > 0$

If we solve the previous equation for q, we obtain the FEER as:

$$FEER = (-\text{KA} - b0 - b2\bar{y}d - b3\bar{y}f)/\ b1$$

The FEER is a method to calculate a real exchange rate that is consistent with medium-term macroeconomic equilibrium.

The BEER is an alternative to FEER and is represented by the equation:

$$qt = \beta 1'Z1t + \beta 2'\ Z2t + \tau'Tt + t$$

Where $Z1$ is a vector of economic fundamentals that are expected to have persistent effects over the long term;

$Z2$ is a vector of economic fundamentals that affect the real exchange rate over the medium term, which may coincide with the business cycle;

$\beta 1$ and $\beta 2$ are vectors of reduced-form coefficients;

T is a vector of transitory factors affecting the real exchange rate in the short term;

τ is a vector of reduced-form coefficients; and

t is a random disturbance term.

The current equilibrium rate q', which is different from the real exchange rate, is the level of the exchange rate given by the current values of the two sets of economic fundamentals:

$$qt' = \beta 1'Z1t + \beta 2'\ Z2t$$

This model is recursive, as the capital account has an impact on both the current and long-term equilibrium exchange rate. The real exchange rate and the real interest rate adjust so that the current account balance is willingly financed by wealth holders. Goldman Sachs (1996, 1997) published a work regarding these methods, and their results appear to support the presumption of the BEER approach that the real exchange rate is related to economic fundamentals.

According to Cardão-Pito's research, the expressions PIGS (Portugal, Ireland, Greece and Spain) or PIIGS (adding Italy to the previous list) were conveyed in academic texts (e.g. Cheng, Wu, Lee & Chang 2014; Fernandes & Mota, 2011; Gärtner, Griesbach & Jung, 2011) and popular media, such as the *Financial Times* and *Economist* (BBC, 2010). One thing these countries have had in common is that they integrated the European single-currency project, the euro, and experienced some form of crisis after integration. Although their economic frameworks, characteristics and performances were quite different, to some extent, they were victims of economic imbalances and institutional shocks due to a poorly structured monetary integration process.

Fig. A.4. displays the GDP growth rate from 1999–2014. In this figure, there are two different periods. One is from 2008 onwards, where the five countries previously referenced had years of economic contraction, or very poor economic growth. However, from 1999–2007, their situations were quite distinct. Portugal and Italy experienced modest GDP growth. Since a significant part of banks' assets are real estate loans (Saunder, Cornett, & McGraw, 2006), banks can be greatly disturbed by shocks in real estate markets. Among the five countries, only Italy had a relatively small current account deficit in 2007.

After the crises, national states again became relevant, and some devolved into self-fulfilling spirals of capital outflows and interest rate increases (Canale, 2015). The five countries and their banks' abilities to obtain funding from foreign financial institutions consequently degraded. Financial markets placed further pressure on these countries (Barbosa & Costa, 2010; De Haas & Van Horen, 2012; Gärtner et al., 2011; Lane, 2012). Fig. A.5. illustrates the worsening of the countries' ten-year debt yields. From 1999–2007, the euro operated as a single currency, showing similar spreads and variations of only a few points among euro-area countries (including Germany). After 2008, however, the spreads became quite larger for the five aforementioned countries, especially Greece. Due to negative consequences and shocks from the crises, these countries' populations were put through some extreme measures that, to some extent, amounted to internal defaults (Cardao-Pito & Baptista, 2015).

Reinhart and Rogoff (2009, 169-170) compared banking crises in different countries and concluded that a banking crisis increases the probability that a country will default on their internal or external creditors.

Portugal is an example of the impact of an unnatural number of banking crises. From 1945 to 2007, Portugal had no banking crises, while the European average was 1.4 banking crises per country (Reinhart and Rogoff, 2009). After 2007, Portugal registered several occurrences of a banking crisis, which may explain the difficulty it faced in meeting the expectations and obligations of its creditors. Adopting the euro may explain this, as Portugal also adopted a market where the exchange rate was absent among countries using the ECU, reducing the real interest rates and financial spreads for Portuguese banks and corporations. As a result of adopting the euro, major Portuguese banks began borrowing money from financial institutions abroad and pumping enormous liquid assets into the Portuguese economy. Eventually, the Portuguese government intervened demanding public funds, leading to a large increase in the national sovereign debt, which increased external and internal defaults (Cardão-Pito & Baptista, 2016).

In agreement with Cardão-Pito & Diogo Baptista (2016), there may be limitations for Portugal that result from adopting the euro. They are the mutation of the Portuguese banking system into a market-based banking system, a lack of adequate European regulations and institutions to implement the euro project and the behaviour of euro-area financial institutions that might have provided high risk loans to Portuguese banks.

In political economics, countries are classified into one of three categories based on their financial systems: government-led credit-based, bank credit-based and capital market-based (Zysman 1983; Hall and Soskice 2001). However, many countries have observed recent mutations, making them no longer classifiable in the traditional typology of capitalism, as these countries rely on what has been called a market-based banking system, which was the case in Portugal (see for instance, Hardie et al. 2013; Hardie and Howarth 2013a).

3. Research question, data and methodology

3.1. Problem

This research aims at observing the relation that exists between the key variables of PPP: inflation rate, interest rate and exchange rate. In the context of the euro, the exchange rate was set as fixed for participating countries, but the other two variables were not. Backus and Smith (1992) tested the real business cycle (RBC) model:

$$\frac{dS}{S} = \eta\left[\left(\frac{dC_1}{C_1} - \frac{d\Pi_1}{\Pi_1}\right) - \left(\frac{dC_2}{C_2} - \frac{d\Pi_2}{\Pi_2}\right)\right] + \frac{d\Pi_1}{\Pi_1} - \frac{d\Pi_2}{\Pi_2}\,. \qquad (1)$$

To study the relation $Y(t) = AX(t)$, Phillips and Loretan (1991) developed an equation with non-linear relations with additional leads and lags empirically,

$$\begin{aligned} Y(t) = AX(t) &+ a_{+1}[Y(t+1) - AX(t+1)] + a_{-1}[Y(t-1) - AX(t-1)] \\ &+ b_{-1}[X(t) - X(t-1)] + c_{-1}[Y(t) - Y(t-1)] + e(t) \qquad (2) \end{aligned}$$

3.1.1 Inflation Rate

Inflation measures variation in the prices of goods and services. When inflation is negative, there is deflation, which means the prices of goods have decreased. In this thesis, inflation is measured through the consumer price index (CPI). This indicator assesses a basket of goods and services that are representative of a country's population. As the prices of these goods will change through time, this allows the researcher to verify the annual price variations, or the country's inflation rate.

3.1.2 Interest Rate

The interest rate is the load of money that the borrower will pay to the granter. The interest rate is the quota at which the interest is indemnified. The mathematical estimation models consider the variable as being positive, which originate issues in the current economic direction. One way that a central bank has to drop the value of the currency is to depreciate its interest rate as stated by Frankena (2016).

3.1.3 Exchange Rate

The exchange rate is the price at which a country's currency can be converted into another country's currency. The nominal exchange rate (NER) is the price of one currency in terms of another, and it is also known as the domestic price of the foreign currency. The real exchange rate (RER) between two currencies is the product of the NER and the ratio of prices between two countries with different currencies, like the yen and the euro following Carbonari (2009) approach.

3.1.4 Nominal and real exchange rate differences

This sub-section explains the differences between RER and NER. Each seems essential to test the PPP theory. They provide a comprehensive overview of the rate of currency exchange between two countries. RER and NER are important variables to understand in order to compare the costs of living between countries with different currencies or with the same currency. The NER defines the value of a given currency that can be traded for a single unit of another. The RER shows the amount of goods or services in a given country that can be exchanged for a single unit of that good or service in a different country. In this study, the NER is considered equal to one in every year for every country, as it is only studied using the euro.

3.2. Tests for PPP

This section demonstrates the empirical proposition regarding the PPP by observing the relationship between inflation, interest and exchange rates; although as mentioned before, the exchange rate is a fixed variable, since it is constant through time as this study deals solely with the euro. Annual data on ten-year bond yields are representative of the interest rate, and the inflation rate is the dependent variable. Real GDP, nominal GDP, government gross debt and trade balance (i.e. exports less imports) are the control variables for the period from 1999–2016 for twelve OECD countries (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain). The previous data were taken from the Eurostat, Bloomberg and Ameco databases.

3.2.1. Multicollinearity

As mentioned by Verbeek [25], multicollinearity is when a linear relationship among explanatory variables leads to unreliable regression estimates. To illustrate this, consider the variance of the ordinary least squares (OLS) estimator of a single coefficient β_k in a multiple regression framework with an intercept as follows:

$$Var(\beta_k) = \frac{\sigma^2}{1 - R_k^2} \frac{1}{N} \left[\frac{1}{N} \sum_{i=1}^{N} (x_{ik} - \bar{x}_k)^2 \right]^{-1}, \qquad k = 2, \dots, K,$$

Where R_k^2 is the squared multiple correlation coefficient between x_{ik} and the other independent variables.

There is a way to detect multicollinearity through the variance inflation factor (VIF):

$$VIF(b_k) = \frac{1}{1 - R_k^2}$$

It indicates the variance of b_k is inflated compared with the hypothetical situation when there is no correlation between x_{ik} and any other independent variable.

3.2.2. Test for unit roots in dynamic panels

Here the properties of the three kinds of panel unit root tests proposed respectively by LL, IPS and MW are presented. Those tests are based on the following regression, which allows for fixed effects and unit-specific time trends:

$$\Delta y_{it} = \gamma_i + \delta_i t + \theta_t + \rho_i y_{it-1} + \zeta_{it}, \quad = 1,2,..\ N,\ t = 1,\ 2,\ \ldots,\ T.$$

Where the error term is $\zeta_{it} \sim (0, \sigma^2)$;

$[\zeta_{it}\zeta_{js}] = 0\ \forall\ t, s$ and $i \neq j$; and

θ_t is the common time effects.

The error term can allow heteroscedasticity and some dependence in the error terms of each unit. The null hypothesis of interest for all three tests is H_0: $\rho_i = 0\ \forall\ i$. The tests allow for different degrees of heterogeneity of ρ_i under the alternative hypothesis if y_{it} is stationary. One of the possible problems when analysing the time series on a number of countries simultaneously is heterogeneity, as it is natural that the model parameters for each country differ. Robertson and Symons (1992) and Pesaran and Smith (1995) mention the importance of heterogeneity in dynamic panel data models and observe the biases that may arise, as they may destroy the relationships between individual series.

Levin and Lin (1992) argue the alternative hypothesis is the case where the autoregressive coefficient is homogeneous across countries (i.e. H_A: $\rho_i = \rho\ \forall\ i$,…, T).

3.2.3. Stationary stochastic process

A stochastic process is stationary if its mean is constant over time, its variance is constant over time and its covariance is constant between two periods. A stochastic process is said to be strictly stationary if its properties are unaffected by a change of time origin, meaning that the joint probability distribution at any set of times $t_1, t_2, \ldots, t_m$ must be the same as the joint probability distribution at times $t_1 + k, t_2 + k, \ldots, t_m + k$. As mentioned before, it must satisfy the following:

$\rightarrow (x_1) = E(x_2) = \cdots = E(x_T) = E(x_t) = \mu,$

and

$\rightarrow Var(x_1) = Var(x_2) = \cdots = Var(x_T) = Var(x_t) = \sigma_2 x,$

$\rightarrow Cov(x_1, x_1 + k) = Cov(x_2, x_2 + k) = \cdots = Cov(x_T - k, x_T) = Cov(x_t, x_t - k)$

This means that the assumption implies the auto covariance

$$\gamma_k = Cov(x_t, x_t - k) = E[(x_t - \mu), (x_t - k - \mu)]$$

And the autocorrelations

$$\rho_k = \frac{Cov(x_t, x_t - k)}{[Var(x_t).Var(x_{t-k})]^{\frac{1}{2}}} = \frac{\gamma_k}{\gamma_0}$$

3.2.4. Cointegration

Let $Xt = (X_{1t}\ X_{2t})'$ be two I(1) variables, such that X_{1t} and X_{2t} contain stochastic trends.

Cointegration occurs if the stochastic trends in X_{1t} and X_{2t} are the same such that they cancel, which is also known as a common trend. Furthermore, if X_{1t} and X_{2t} cointegrate, then the deviation $u_t = X_{1t} - \mu - \beta_2 X_{2t}$ is a stationary process with a mean of zero. If X_{1t} and X_{2t} do not cointegrate, then the deviation u_t is I(1).

The Engel and Granger approach becomes relevant to understand that cointegration requires a combination of the variables to be stationary. Consider the equilibrium demand for money equation:

$$mt - pt = \beta 1 + \beta 2yt + \beta 3rt + t,$$

Where m is money demand, p is the price level, y is the real income and r is the interest rate. It is required that $\beta_2 > 0$ and $\beta_3 < 0$.

(i) The linear transformation of any process keeps its order of integration:

$x_t \sim (0) \Rightarrow \alpha + \beta x_t = z_t \sim I(0)$; $y_t \sim I(1) \Rightarrow \alpha + \beta y_t = p_t \sim I(1)$

(ii) If both x_t and y_t are stationary, then the combination of these two processes is a stochastic process

$$x_t \sim (0), y_t \sim I(0) \Rightarrow \alpha x_t + \beta y_t = z_t \sim I(1)$$

(iii) The linear combination between a stochastic process and a process of a degree equal to one results in an integrated process with a degree of one (i.e. $I(1)$ is a dominant property)

$$x_t \sim (0), y_t \sim I(1) \Rightarrow \alpha x_t + \beta y_t = z_t \sim I(1)$$

(iv) The combination of two processes of order one is an order one process

$$x_t \sim (1), y_t \sim I(1) \Rightarrow \alpha x_t + \beta y_t = z_t \sim I(1)$$

(v) The combination of two processes of order one is an order one process

$$x_t \sim (1), y_t \sim I(1) \Rightarrow \alpha x_t + \beta y_t = z_t \sim I(1)$$

(vi) There are some exceptions to the previous conditions, as the linear combination may be (0). So, x and y are cointegrated (i.e. there is a stationary equilibrium between these two variables)

$$x_t \sim (1), y_t \sim I(1) \Rightarrow \alpha x_t + \beta y_t = z_t \sim I(0)$$

3.3.1. Univariate processes with unit processes

Following Hamilton's (1994) approach, consider the OLS estimation of a Gaussian (1) process,

$$y_t = py_{t-1} + u_t \qquad t = 1, \dots, n$$

Where u_t~i.i.d. $(0, \sigma^2)$, and $y_0 = 0$.

From the previous information, certain properties according to Stock (1987) follow:

(i) When the variables are cointegrated, then the estimator is consistent.

(ii) When using finite samples, the skewness of the estimator may be significative, as the expected value may not coincide with the true values of the parameters, which makes the study of cointegration for short periods of time difficult.

(iii) The OLS estimator is not asymptotically efficient.

(iv) Generally, the asymptotic distribution theory is not valid.

3.3.2. Test for Cointegration

McCoskey and Kao (1998) propose the use of the average of the augmented Dickey-Fuller (ADF) statistics over cross-sections, based on Im et al. (1997), to test the hypothesis that no cointegration exists in heterogeneous panels.

First consider two time series x_{1t} andx_{2t}, which are both I(1), meaning that each series has a unit root. If the two series cointegrate, than the coefficients are μ and β_2 such that

$$x_{1t} = \mu + \beta_2 x_{2t} + u_t$$

By using the Engle-Granger approach, first the series would need to be tested for their unit roots. If both are I(1), than the defined regression equation must be run and the residuals must be saved, as these must be tested for a unit root. If the null hypothesis for the residuals is rejected, than the hypothesis of the two variables cointegrating cannot be rejected.

If one of the series is stationary (i.e. I[0]) and the other is I(1), they cannot be cointegrated since cointegration implies that they share common stochastic trends and that a linear relationship between them is stationary since the stochastic trends will cancel and thereby produce a stationary relationship.

So, the steps that should be followed using dynamic OLS are:

1. Select the optimal lag of leads and lags using information criteria;
2. Estimate the equation by OLS and test whether the residuals are I(0) or I(1) according to the ADF test. If the residuals are I(0), the variables are cointegrated.

4. PPP and cointegration: The euro case

4.1. The approach employed

In order to use the nominal GDP and real GDP as one variable, the GDP deflator was used to make a division between the first variable and the second. Furthermore, the trade balance was calculated using exports and imports, as previously mentioned. The logarithm was then applied to all variables. The reason for the existence of the previous variable is due to its correlation with respect to the inflation rate.

Here the NER is dropped due to its statistical characteristics. Therefore, for each of the countries in the euro area, there are two variables considered dependent, one of which is the inflation rate. The other variable is the interest rate, which corresponds to the annual yields on ten-year bonds.

There are two types of tests that are presented in this paper. The first uses the variables of the studied twelve countries as panel data. The second studies each country individually in order to understand the relationship between the dependent and independent variables and observe differences in their behaviour between countries.

4.2. Panel unit root testing

The panel unit root has been tested with the joint null hypothesis of a unit root for each country. Some issues when doing panel data tests are cross-sectional dependence, heterogeneity in dynamics and error-term properties. So, this section presents the basic statistics for each dependent variable and its histogram, but only for LOG_INFLATON_RATE and LOG_INTEREST_RATE, as NER is a vector with equal values in every entry; hence, it has no variance and therefore no relation with the previous variables. This is done for the panel data and the countries separately. These can be seen in the tables below.

The unit root test was conducted for inflation rate and interest rate. As explained before, the purpose of this test is to check the null hypothesis that there is unit root data or that the data are not stationary. Thus, in the statistical package, the unit root test has been applied to check whether the data is stationary. It can be seen in the tables, in relation to the unit root test for the countries, that none of the countries have a stationary inflation rate variable. Furthermore, some countries, like Belgium, do not have this variable as stationary, which should not happen due to the relation between inflation, interest and exchange rates.

The interest rate in the case of Ireland is not stationary, which should also not happen. This means that the relationship between the previous two variables is not the same in the countries and that the panel data test cannot correctly present the stationarity for each country.

		Austria		Belgium		Finland		France		Germany		Greece	
Variables	Methods	Statistics values	Conclusion	Statistics values	Conclusion	Statistics values	Conclusion	Statistics values	Conclusion	Statistics values	Conclusion	Statistics values	Conclusion
Inflation rate	Augmented Dickey-Fuller (intercept)	-5.425*** (0.000)	I(1)***	-4.355*** (0.004)	Not stationary	-2.240 (0.200)	Not stationary	-6.588*** (0.000)	I(1)**	-4.795*** (0.002)	I(1)***	-5.070*** (0.001)	I(1)***
	Augmented Dickey-Fuller (trend and intercept)	-5.488*** (0.002)	I(1)***	-4.531* (0.011)	Not stationary	-2.260 (0.430)	Not stationary	-4.025** (0.034)	I(1)**	-4.951*** (0.006)	I(1)***	-5.043*** (0.005)	I(1)***
	Augmented Dickey-Fuller (no trend and no intercept)	-5.616*** (0.000)	I(1)***	-1.016 (0.264)	Not stationary	-1.231 (0.191)	Not stationary	-6.759*** (0.000)	I(1)**	-4.916*** (0.000)	I(1)***	-5.128*** (0.000)	I(1)***
	Levin, Lin & Chu t*												
	Im, Pesaran and Shin W-stat												
	ADF - Fisher Chi-square												
	PP - Fisher Chi-square												
Interest rate	Augmented Dickey-Fuller (intercept)	-5.331*** (0.000)	I(1)***	-5.360*** (0.000)	I(1)***	-4.837*** (0.001)	I(1)***	-5.648*** (0.000)	I(1)***	-5.487*** (0.000)	I(1)**	-3.538* (0.021)	I(1)*
	Augmented Dickey-Fuller (trend and intercept)	-5.331*** (0.003)	I(1)***	-5.337*** (0.003)	I(1)***	-4.816*** (0.007)	I(1)***	-5.642*** (0.001)	I(1)***	-4.515** (0.014)	I(1)**	-3.404* (0.088)	I(1)*
	Augmented Dickey-Fuller (no trend and no intercept)	-3.976*** (0.000)	I(1)***	-4.538*** (0.000)	I(1)***	-3.501*** (0.001)	I(1)***	-4.270*** (0.000)	I(1)***	-4.044*** (0.000)	I(1)**	-3.676* (0.000)	I(1)*
	Levin, Lin & Chu t*												
	Im, Pesaran and Shin W-stat												
	ADF - Fisher Chi-square												
	PP - Fisher Chi-square												

Table 4.2.1. Results of unit root tests for the panel data and euro-area countries from Austria to Greece

		Ireland		Italy		Luxembourg		Netherlands		Portugal		Spain		Panel Data	
Variables	Methods	Statistics values	Conclusion	Statistics values	Conclusion	Statistics values	Conclusion	Statistics values	Conclusion	Statistics values	Conclusion	Statistics values	Conclusion	Statistics values	Conclusion
	Augmented Dickey-Fuller (intercept)	-4.013** (0.009)	I(1)**	-4.860** (0.001)	I(1)**	-6.442*** (0.000)	I(1)***	-5.564*** (0.000)	I(2)***	-4.773** (0.002)	I(1)**	-6.138*** (0.000)	I(1)***		
	Augmented Dickey-Fuller (trend and intercept)	-3.842** (0.043)	I(1)**	-3.828** (0.047)	I(1)**	-6.328*** (0.000)	I(1)***	-5.566*** (0.002)	I(2)***	-4.601** (0.013)	I(1)**	-6.131*** (0.000)	I(1)***		
	Augmented Dickey-Fuller (no trend and no intercept)	-3.965** (0.000)	I(1)**	-4.902** (0.000)	I(1)**	-6.519*** (0.000)	I(1)***	-5.712*** (0.000)	I(2)***	-4.316** (0.000)	I(1)**	-6.100*** (0.000)	I(1)***		
Inflation rate	Levin, Lin & Chu t*													-4.653*** (0.000)	I(0)***
	Im, Pesaran and Shin W-stat													-3.317*** (0.000)	I(0)***
	ADF - Fisher Chi-square													49.261*** (0.001)	I(0)***
	PP - Fisher Chi-square													50.522*** (0.001)	I(0)***
	Augmented Dickey-Fuller (intercept)	-2.922 (0.064)	Not stationary	-4.083 (0.007)	I(1)**	-5.200*** (0.001)	I(1)***	-5.292*** (0.000)	I(1)***	-6.092*** (0.000)	I(2)***	-4.551* (0.003)	I(2)*		
	Augmented Dickey-Fuller (trend and intercept)	-2.908 (0.185)	Not stationary	-3.990 (0.032)	I(1)**	-4.996*** (0.006)	I(1)***	-5.288*** (0.003)	I(1)***	-5.858*** (0.001)	I(2)***	-3.819* (0.054)	I(2)*		
	Augmented Dickey-Fuller (no trend and no intercept)	-2.944 (0.006)	Not stationary	-4.024 (0.000)	I(1)**	-5.395*** (0.000)	I(1)***	-3.956*** (0.000)	I(1)***	-6.319*** (0.000)	I(2)***	-4.723* (0.000)	I(2)*		
Interest rate	Levin, Lin & Chu t*													-13.202*** (0.000)	I(1)***
	Im, Pesaran and Shin W-stat													-10.367*** (0.000)	I(1)***
	ADF - Fisher Chi-square													131.415*** (0.000)	I(1)***
	PP - Fisher Chi-square													139.946*** (0.000)	I(1)***

Table 4.2.2. Results of unit root tests for the panel data and euro-area countries from Ireland to Spain

4.3. Cointegration Testing

A cointegrating relationship requires the variables to be at least integrated at order one, I(1). To carry out a cointegration analysis, it is necessary to conduct a unit root test to see if the time series are in fact I(1). Afterwards, it is possible to conduct a cointegration test on the relevant series. One of the most popular tests is Johansen's trace test/maximum eigenvalue test. This test is required to work with every variable. Therefore, in this section, the variables LOG_INFLATION_RATE is the dependent variable and LOG_INTEREST_RATE, LOG_DEFLATOR_GDP, LOG_GOVERNMENT_GROSS_DEBT and LOG_TRADE_BALANCE are independent variables for the panel data, as it is not possible to do this for every country. It is only required to test cointegration for one variable as dependent, since this test is directly related to the stationarity of each variable. Hence, if the dependent variable is I(2) and one of the independent variables is I(1) and the linear relation is I(1) then cointegration is confirmed.

First, the Pedroni residual cointegration test was computed for the previous variables. It tested H_0: there is no cointegration in this model. There is no deterministic trend in the panel cointegration. There are two scenarios that are presented: H_1 within-dimension and between-dimension, with four different statistics for each scenario. For the v-stat and rho-stat, we accept H_0, and for the PP-stat and ADF-stat, we reject H_0 and accept H_1, meaning the variables are cointegrated. As most of the p-values are significant in eleven tests, H_1 is accepted. Therefore, the five variables are cointegrated; they have a long-term association.

Next, the results are checked for a deterministic trend in individual intercepts and trends. It can be seen that out of eleven outcomes, six are significant for all significance levels. So, H_1 is accepted, meaning that the variables are cointegrated for this trend.

Finally, the no intercept or trend option is checked. Six out of eleven probabilities are significant, so the majority of the p-values reject H_0. Hence, the variables are cointegrated. All the tests conclude that the variables are cointegrated.

Then, the Kao residual cointegration test is checked. The probability of ADF is less than 1%, so H_0 is rejected for all levels of significance. Thus, the five variables are cointegrated.

	Deterministic trend specification				
Statistics values	no trend	intercept and trend	no intercept or trend	Kao	Conclusion
Panel v-Statistic	0.108 (0.456)	-1.251 (0.894)	0.262 (0.396)		No Cointegration
Panel rho-Statistic	0.731 (0.767)	1.674 (0.953)	-0.396 (0.346)		No Cointegration
Panel PP-Statistic	-5.750*** (0.000)	-6.989*** (0.000)	-4.603*** (0.000)		Cointegration
Panel ADF-Statistic	-5.555*** (0.000)	-6.907*** (0.000)	-5.006*** (0.000)		Cointegration
Panel v-Statistic (Weighted)	-0.984 (0.837)	-2.520 (0.994)	-0.436 (0.669)		No Cointegration
Panel rho-Statistic (Weighted)	0.799 (0.788)	1.699 (0.955)	-0.269 (0.394)		No Cointegration
Panel PP-Statistic (Weighted)	-6.946*** (0.000)	-7.561*** (0.000)	-5.276*** (0.000)		Cointegration
Panel ADF-Statistic (Weighted)	-6.725*** (0.000)	-7.125*** (0.000)	-5.584*** (0.000)		Cointegration
Group rho-Statistic	2.136 (0.983)	2.899 (0.998)	0.824 (0.795)		No Cointegration
Group PP-Statistic	-10.211*** (0.000)	9.840*** (0.000)	-6.753*** (0.000)		Cointegration
Group ADF-Statistic	-6.904*** (0.000)	-7.138*** (0.000)	-6.924*** (0.000)		Cointegration
ADF				-6.721*** (0.000)	Cointegration

Table 4.3.1. Results of residual cointegration tests for all variables

4.4. Estimating Equation

This development consists of working the panel data using the pooled OLS regression model, fixed effect or Least Squares Dummy Variable (LSDV) model and the random effect model. As there are two dependent variables, it was run in two ways: one with the interest rate as the dependent variable and one with inflation rate as the dependent variable.

The first model pooled all the observations together and ran the regression model, neglecting the cross-section and the time series nature of the data. The major problem with this model is that it denies the heterogeneity that may exist among the countries.

The second model allows for heterogeneity among the countries by allowing it to have its own intercept value. The fixed effect is due to the fact that although the intercept may differ across the countries, it does not vary over time (i.e. it is time invariant).

Finally, in the third model, the countries have a common mean value for the intercept.

After running the above three models, the best model to accept was determined using the Hausman test, where H_0 is the random-effects model.

Hence, for the inflation rate variable, the pooled regression model concluded that LOG_GOVERNMENT_GROSS_DEBT and LOG_TRADE_BALANCE are significant variables to explain LOG_INFLATION_RATE for all significance levels. In this case, the fixed effect model was run after the correlated random effects–Hausman test. However, when using LOG_INTEREST_RATE as a dependent variable, LOG_INFLATION_RATE and LOG_DEFLATOR_GDP are significant variables to explain the variable at a significance level of 5%. Here, the random effects model is accepted according to the Hausman test. The first two tables illustrate the panel data regression.

Variables	Panel Data	Austria	Belgium	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain
CONSTANT	0.086***	-21.871	46.761*	14.954	78.756**	-31.938*	-2.256	10.538**	70.461*	15.943	-12.263	10.875	-4.263
	(0.000)	(0.537)	(0.099)	(0.390)	(0.019)	(0.066)	(0.939)	(0.017)	(0.063)	(0.451)	(0.722)	(0.697)	(0.763)
LOG_INTEREST_RATE	0.0005	0.385	0.002	1.112	-0.587	-0.536	0.181*	-0.073	0.640**	0.403	0.606	0.302*	0.561**
	(0.311)	(0.292)	(0.993)	(0.122)	(0.218)	(0.252)	(0.051)	(0.743)	(0.016)	(0.299)	(0.340)	(0.064)	(0.019)
LOG_DEFLATOR_GDP	-0.0009	-8.887	6.899	11.966	13.539	-35.852**	-7.660	-1.882	15.582*	20.907	-4.309	0.642	-3.722
	(0.5842)	(0.670)	(0.286)	(0.204)	(0.199)	(0.015)	(0.570)	(0.753)	(0.095)	(0.477)	(0.765)	(0.969)	(0.429)
LOG_GOVERNMENT_GROSS_DEBT	-0.012***	3.663	-7.161	-3.135	-10.195**	3.846*	-0.246	-1.900*	-9.191*	-2.324	1.802	-2.103	0.480
	(0.000)	(0.532)	(0.115)	(0.374)	(0.018)	(0.085)	(0.958)	(0.066)	(0.062)	(0.447)	(0.630)	(0.669)	(0.811)
LOG_TRADE_BALANCE	-0.0001***	0.705	-1.074**	-0.245	-0.038**	0.445*	-0.161***	-0.032	0.010	-3.162	0.296	-0.005	-0.023
	(0.001)	(0.286)	(0.022)	(0.074)	(0.042)	(0.095)	(0.003)	(0.982)	(0.456)	(0.555)	(0.934)	(0.962)	(0.133)
R-squared	0.294	0.179	0.484	0.443	0.541	0.486	0.541	0.541	0.684	0.222	0.338	0.571	0.746
No. Observations	216	18	18	18	18	18	18	18	18	18	18	18	18

Standard errors are reported in parentheses.
*, **, *** indicates significance at the 90%, 95%, and 99% level, respectively

Table 4.4.1. Regression results for LOG_INFLATION_RATE as a dependent variable

Variables	Panel Data	Austria	Belgium	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain
CONSTANT	4.396***	1.190	43.417*	11.738*	62.525***	-1.660	-15.044	6.409	-73.904**	-20.749	43.676***	-91.053**	23.496
	(0.000)	(0.964)	(0.057)	(0.057)	(0.000)	(0.879)	(0.856)	(0.268)	(0.036)	(0.156)	(0.000)	(0.027)	(0.101)
LOG_INFLATION_RATE	21.098**	0.220	0.002	0.156	-0.194	-0.185	1.442*	-0.100	0.575**	0.204	0.115	0.789*	0.636**
	(0.044)	(0.292)	(0.292)	(0.122)	(0.217)	(0.252)	(0.051)	(0.761)	(0.016)	(0.299)	(0.340)	(0.064)	(0.018)
LOG_DEFLATOR_GDP	-0.563**	-14.096	-3.116	-4.832	5.709	-27.760***	12.704	-7.384	-20.559**	-34.954*	11.526**	-50.512**	6.177
	(0.035)	(0.367)	(0.562)	(0.169)	(0.353)	(0.000)	(0.739)	(0.292)	(0.013)	(0.078)	(0.048)	(0.045)	(0.210)
LOG_GOVERNMENT_GROSS_DEBT	-0.172	-0.176	-6.732*	-2.251	-8.105***	0.107	4.888	1.554	9.849**	2.394	-4.359***	16.625**	-3.029
	(0.321)	(0.968)	(0.066)	(0.074)	(0.000)	(0.938)	(0.713)	(0.226)	(0.030)	(0.264)	(0.001)	(0.021)	(0.139)
LOG_TRADE_BALANCE	-0.008	0.060	-0.675*	0.054	-0.027***	0.159	0.291*	-2.972*	-0.033***	5.467	-3.555**	-0.315*	0.030*
	(0.132)	(0.906)	(0.094)	(0.314)	(0.006)	(0.325)	(0.086)	(0.076)	(0.004)	(0.137)	(0.010)	(0.067)	(0.055)
R-squared	0.078	0.848	0.815	0.955	0.939	0.953	0.551	0.365	0.793	0.701	0.911	0.524	0.577
No. Observations	216	18	18	18	18	18	18	18	18	18	18	18	18

Standard errors are reported in parentheses.
*, **, *** indicates significance at the 90%,
95%, and 99% level, respectively

Table 4.4.2. Regression results for LOG_INTEREST_RATE as a dependent variable

4.5. Covariance and Correlation matrices

The relationships between variables are well represented in covariance and correlation matrices, as covariance measures the joint variability between random variables and correlation (i.e. the statistical relationship regarding the dependence for variables). Covariance, unlike correlation, is not constrained to being between -1 and 1. Therefore, the matrices of covariance and correlation between the two variables LOG_INFLATION_RATE and LOG_INTEREST_RATE are presented below:

	Panel Data	Austria	Belgium	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain
Correlation between LOG_INFLATION RATE and LOG_INTEREST_RATE	0.222	0.105	0.338	0.285	0.440	0.247	-0.166	0.066	0.746	0.427	0.567	0.369	0.645
Covariance between LOG_INFLATION RATE and LOG_INTEREST_RATE	0.006	0.120	0.488	0.446	0.492	0.279	-1.182	0.249	0.932	0.835	0.980	1.102	1.142

Standard errors are reported in parentheses.

*, **, *** indicates significance at the 90%,

95%, and 99% level, respectively

Matrix 4.5.1. Table of covariances and correlations between LOG_INFLATION RATE and LOG_INTEREST_RATE for the panel data and singular countries

4.6. Panel DOLS model

There are some conditions to test the panel cointegration using Eviews. First, the variables must be stationary on the same order. Then, if and only if a variable is cointegrated, the DOLS model is applied to the panel data for long-term relationships. Thus, all of the variables available are used: LOG_INFLATION_RATE, LOG_INTEREST_RATE, LOG_DEFLATOR_GDP, LOG_GOVERNMENT_GROSS_DEBT and LOG_TRADE_BALANCE.

A cointegration regression is conducted for all variables with LOG_INFLATION_RATE as the dependent variable and no trend specification with the DOLS method or group panel method. As the p-values are less than 1% for LOG_INTEREST_RATE and LOG_TRADE_BALANCE, this means that for LOG_INFLATION_RATE, the previous variables are significant. LOG_TRADE_BALANCE has a negative association with LOG_INFLATION_RATE, and LOG_INTEREST_RATE has a positive association with LOG_INFLATION_RATE. This can be seen in *Table 4.6.1* with LOG_INTEREST_RATE and LOG_INFLATION_RATE as dependent variables in each case.

	Dependent Variable	
	LOG_INFLATION_RATE	LOG_INTEREST_RATE
LOG_INTEREST_RATE	0.003***	
	(0.005)	
LOG_INFLATION_RATE		34.738***
		(0.005)
LOG_DEFLATOR_GDP	-0.007	-8.250***
	(0.773)	(0.000)
LOG_GOVERNMENT_GROSS_DEBT	0.001	0.484***
	(0.357)	(0.007)
LOG_TRADE_BALANCE	-0.0008***	0.004
	(0.001)	(0.897)
R-squared	-5.743	-3.513
No. Observations	204	204

Standard errors are reported in parentheses.
*, **, *** indicates significance at the 90%, 95%, and 99% level, respectively

Table 4.6.1. Regression results for panel DOLS model

4.7. Pairwise Granger Causality

This causality test is closely related to the idea of cause and effect, although it is not exactly the same. For instance, a variable X is causal to variable Y if X is the cause of Y or Y is the cause of X. The objective of the test is to know if a particular variable comes before another in a time series. In other words, Granger causality does not indicate a causal link. The null hypothesis for the test is that lagged x-values do not explain the variation in y. This test was conducted for each of the countries presented below:

	Austria	Belgium	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain
LOG_INTEREST_RATE does not Granger Cause LOG_INFLATION_RATE	0.536	3.063*	1.078	6.304**	3.912*	7.014**	0.949	3.919*	1.021	3.536*	1.208	3.446*
	(0.599)	(0.087)	(0.373)	(0.015)	(0.052)	(0.011)	(0.416)	(0.051)	(0.391)	(0.065)	(0.335)	(0.068)
LOG_INFLATION_RATE does not Granger Cause LOG_INTEREST_RATE	0.894	0.358	0.697	0.041	1.257	0.433	2.864*	0.271	1.845	0.088	1.389	0.715
	(0.437)	(0.706)	(0.518)	(0.959)	(0.322)	(0.658)	(0.099)	(0.767)	(0.203)	(0.916)	(0.289)	(0.510)

Standard errors are reported in parentheses.

*, **, *** indicates significance at the 90%,

95%, and 99% level, respectively

Table 4.7.1. Results of pairwise Granger causality test for the variables LOG_INFLATION_RATE and LOG_INTEREST_RATE

5. Findings and their limitations

5.1. Summary of findings

The Phillips-Perron (1988) unit root test was the first regression model by OLS to be tested. Thus, whether the model has a unit root is checked, and the null hypothesis (H_0: there is unit root) is rejected if the series is not stationary. From *Tables 4.2.1* and *4.2.2,* it can be concluded that the inflation rate is stationary on level and the interest rate is stationary after first difference. For the cointegration test, *Table 4.3.1* shows the results. According to Johansen (1992), if all of the tests suggest that the variables are cointegrated, then cointegration between the variables is confirmed.

In addition, it is necessary to estimate the equation from each country in order to understand the importance of the variables for each country, respectively. The results can be seen in *Tables 4.4.1* and *4.4.2* using LOG_INFLATION_RATE and LOG_INTEREST_RATE, which verify that between these two variables there are similar results for each country (and panel data); however, when crossing the information, significant differences from the estimation can be seen (e.g. Germany and Greece). This should not happen, as PPP theory would mean that all the countries should have identical results since the relationship of the two previous variables should be equivalent. The correlation and covariance is a good example of the previous summary, as there are several discrepancies between the correlation and covariance of LOG_INFLATION_RATE and LOG_INTEREST_RATE, as France has a positive covariance and correlation, but Greece has a negative covariance and correlation. This means that the relationship between the previous variables varies.

From the panel DOLS model, it can be concluded that significant variables with p-values at a less than 10% significance level means that the error correction term is statistically significant in affecting the short-term dynamic. Hence, the results show that interest rate is affected by inflation rate, GDP and gross debt, whereas inflation rate is affected by interest rate and trade balance.

Finally, the causality test concluded that, in general, inflation rate is not causal to interest rate, though some countries' (i.e. Belgium, France, Germany, Greece, Italy, Netherlands and Spain) data rejected the null hypothesis, meaning that for these cases, interest rates may explain the variation in inflation rate.

5.2. Limitations

During the research, in order to test the PPP theory for euro-area countries, some difficulties arose. The theory itself does not consider that there are non-identical products between countries; therefore, some products may not be tradable. Additionally, the sample was small one, as only twelve out of nineteen cases had all the information required; the countries that were not present in the study had information missing. Indeed, this happened due to the absence of these countries from the euro area during the introduction of the euro as a currency. As referred to previously, the short period of study could be a limitation of this research. Finally, the biggest issue for this study was that it was not possible to reproduce previous studies (e.g. USD\EUR and USD\GBP).

6. Conclusion

The objectives of this paper are emphasized once again to see if the expectations were met and to raise relevant questions on this topic. The theory of PPP, in line with Mackinnon as stated by Taylor (1988), says:

> *Until a more robust theory replaces it, I shall assume that purchasing power parity among tradeable goods tends to hold in the long run in the absence of overt impediments to trade among countries with convertible currencies.*

This theory was studied with econometric models. The first step was to obtain variables through known platforms including Bloomberg, Eurostat and Ameco. Next, the exchange rate in this case is a time series equal to one in every entry for every country, meaning that the euro in country i has the same value as in country j. This was a problem when trying to conduct a regression and the tests for stationarity and cointegration, as the variable of exchange rate could not enter the study for reasons of multicollinearity.

Therefore, the variables had to be tested as described in chapter four. The results are described in chapter five. As explained previously, the results did not support the theory, as the behaviours of the variables over time with respect to each country were not similar. They should have been similar, since the exchange rate was equal to one in this case for all countries, which was the main variable in this study. This is a reason to refute the PPP theory's application in the euro area.

In comparison to previous studies of PPP with different approaches, the relationship between exchange, inflation and interest rates differs depending on the economy and other factors besides the euro that may influence the dynamics of these countries. To conclude, the result of the panel Vector Equilibrium Correction Model (VECM) (twelve countries from 1999–2016) is not in line with the theoretical expectations.

Bibliography

[1] Abuaf, Niso & Jorion, Philippe, 1990, “Purchasing power parity puzzle,” *Journal of Finance,* Vol. XLV, pp. 157-173

[2] Alan Taylor & Mark P. Taylor, 2004. “The Purchasing Power Parity Debate,” *Journal of Economic Perspectives*, vol. 18(4), pages 135-158.

[3] Alan Taylor, 2002. “A Century of Purchasing-Power Parity,” *The Review of Economics and Statistics, MIT Press*, vol. 84(1), pages 139-150, February.

[4] Alston, Lee J., 2003. “Access to land, rural poverty and public action: Edited by Alain de Janvry, Gustavo Gordillo, Jean-Philippe Platteau, and Elisabeth Sadoulet. Oxford: Oxford University Press, 2001. Pp. xiii, 451,” *Journal of Development Economics*

[5] Bordo, Michael “The Classical Gold Standard: Some Lessons for Today.” *Federal Reserve Bank of St. Louis Review*, May 1981, pp. 2-17.

[6] Campa, Jose and Goldberg, Linda, 2008 “Pass-through of exchange rates to consumption prices: what has changed and why?”, *International Financial Issues in the Pacific Rim: Global Imbalances, Financial Liberalization, and Exchange Rate Policy, pages 139-176 National Bureau of Economic Research, Inc.*

[7] Cardão-Pito, Tiago and Baptista, Diogo (2017). "Portuguese banking and financial crises: Unexpected consequences of monetary integration?" *Journal of Economic Policy Reform*, 20 (2), 165-191

[8] Cardão-Pito, Tiago (2017). "Are they all the same? Banking and financial crises in debtridden Euroarea countries". *International Finance Review*, 18.

[9] Cavallo, Antonella & Ribba, Antonio, 2014. "Euro area inflation as a predictor of national inflation rates," *Journal of Policy Modeling, Elsevier*, vol. 36(6), pages 10481065.

[10] Engel, Charles; John Rogers (1996). "How Wide is the Border?" *(PDF). American Economic Review*. 86: 1112–25. Retrieved 19 January 2014.

[11] Engel, Charles, (2016), "Exchange Rates, Interest Rates, and the Risk Premium", *American Economic Review*, 106, issue 2, p. 436-74.

[12] Friedman, Milton; and Robert Roosa. "Free Versus Fixed Exchange Rates: A Debate." *Journal of Portfolio Management, Spring 1977*, pp. 68-73.

[13] Giddy, Ian and Gunter Dufey. "The Random Behavior of Flexible Exchange Rates," *Journal of International Business Studies*, Spring 1975, pp. 1-32.

[14] Hahn, E, "The impact of exchange rate shocks on sectoral activity and prices in the euro area", *ECB Working Paper Series*, No 796, August 2007.

[15] Investopedia (2016) "What Is Purchasing Power Parity? (PPP)". 02 Nov. 2016. Web. 06 Jun. 2017

[16] Jean Imbs & Haroon Mumtaz & Morten Ravn & Hélène Rey, 2005. "PPP Strikes Back: Aggregation and the Real Exchange Rate," *The Quarterly Journal of Economics, MIT Press*, vol. 120(1), pages 1-43, January.

[17] Kenneth Rogoff, 1996. "The Purchasing Power Parity Puzzle," *Journal of Economic Literature, American Economic Association*, vol. 34(2), pages 647-668, June.

[18] LAV Catão, "Why Real Exchange Rates", *Finance and Development*, September 2007, pp.46-47

[19] Linneman, Ludger, 2005. "Can raising interest rates increase inflation?" *Economics Letters, Elsevier*, vol. 87(3), pages 307-311, June.

[20] Persson, Karl. "Law of One Price". *EH.Net Encyclopedia, edited by Robert Whaples*. February 10, 2008. Available from: http://eh.net/encyclopedia/the-law-of-one-price/

[21] Rogoff, K. (1996), "The purchasing power parity puzzle," *Journal of Economic Literature, Vol. XXXIV*, pp. 647-668

[22] Shapiro, Alan, "Foundations of Multinational Financial Management," *Allyn and Bacon* (1991)

[23] Szwarczynski, Eric (2008). "Biting into the Big Mac" *(Erasmus University Thesis Repository)*

[24] Verbeek, Marno, "A Guide to Modern Econometrics", *Chichester : John Wiley*, 2008 . 472 p.

[25] Zhang, Kai (2012), "Does Purchasing Power Parity hold between European countries?", *MSc Management and Marketing*

Appendix A

Data and Graphics

A.1 Data

Year	Country	GDP real	GDP Nominal	Deflator GDP	LOG_DEFLATOR_GDP	Government gross debt	LOG_GOVERNMENT_GROSS_DEBT	Inflation rate	LOG_INFLATION_RATE	Interest rate	LOG_INTEREST_RATE	Nominal Exchange Rate	LOG_NOMINAL_EXCHANGE_RATE	Exportations	Importations	Trade Balance	LOG_TRADE_BALANCE
1999	Austria	245.445	177.510	0.723	-0.324	135.1	4.906	0.500	0.499	5.350	5.212	1.000	0.000	80.230	79.208	1.021	0.021
2000	Austria	253.713	186.684	0.736	-0.307	140.4	4.944	2.000	1.980	5.210	5.079	1.000	0.000	92.591	89.636	2.954	1.083
2001	Austria	257.139	192.533	0.749	-0.289	146.3	4.986	2.300	2.274	4.950	4.831	1.000	0.000	98.367	94.522	3.845	1.347
2002	Austria	261.397	197.722	0.756	-0.279	150.5	5.014	1.700	1.686	4.430	4.335	1.000	0.000	102.536	94.257	8.279	2.114
2003	Austria	263.374	202.502	0.769	-0.263	151.9	5.023	1.300	1.292	4.380	4.287	1.000	0.000	102.980	96.816	6.164	1.819
2004	Austria	270.500	211.959	0.784	-0.244	157.2	5.058	2.000	1.980	3.630	3.566	1.000	0.000	113.305	106.306	6.999	1.946
2005	Austria	276.290	222.032	0.804	-0.219	173.6	5.157	2.100	2.078	3.360	3.305	1.000	0.000	123.040	115.198	7.842	2.060
2006	Austria	285.548	234.732	0.822	-0.196	179.4	5.190	1.700	1.686	3.810	3.739	1.000	0.000	135.455	126.307	9.148	2.214
2007	Austria	295.889	248.541	0.840	-0.174	183.8	5.214	2.200	2.176	4.350	4.258	1.000	0.000	148.190	136.469	11.722	2.461
2008	Austria	300.468	256.820	0.855	-0.157	201.0	5.303	3.200	3.150	3.900	3.826	1.000	0.000	155.175	142.959	12.217	2.503
2009	Austria	289.053	251.008	0.868	-0.141	229.2	5.435	0.400	0.399	3.610	3.546	1.000	0.000	128.487	119.945	8.542	2.145
2010	Austria	294.628	258.361	0.877	-0.131	243.9	5.497	1.700	1.686	3.430	3.372	1.000	0.000	150.271	140.477	9.794	2.282
2011	Austria	302.901	269.994	0.891	-0.115	260.1	5.561	3.600	3.537	3.100	3.053	1.000	0.000	165.648	157.871	7.777	2.051
2012	Austria	305.160	276.752	0.907	-0.098	262.3	5.569	2.600	2.567	1.770	1.755	1.000	0.000	170.599	162.374	8.225	2.107
2013	Austria	305.539	281.275	0.921	-0.083	279.0	5.631	2.100	2.078	2.170	2.147	1.000	0.000	171.566	163.239	8.327	2.120
2014	Austria	307.509	288.347	0.938	-0.064	290.5	5.672	1.500	1.489	0.810	0.807	1.000	0.000	175.175	164.271	10.904	2.389
2015	Austria	310.470	296.094	0.954	-0.047	295.7	5.689	0.800	0.797	0.860	0.856	1.000	0.000	180.350	166.726	13.624	2.612
2016	Austria	315.071	304.534	0.967	-0.034	298.3	5.698	1.000	0.995	0.530	0.529	1.000	0.000	182.492	169.186	13.306	2.588

Year	Country	GDP real	GDP Nominal	Deflator GDP	LOG_DEFLATOR_GDP	Government gross debt	LOG_GOVERNMENT_GROSS_DEBT	Inflation rate	LOG_INFLATION_RATE	Interest rate	LOG_INTEREST_RATE	Nominal Exchange Rate	LOG_NOMINAL_EXCHANGE_RATE	Exportations	Importations	Trade Balance	LOG_TRADE_BALANCE
1999	Belgium	300.542	216.320	0.720	-0.329	279.4	5.633	1.100	1.094	5.410	5.269	1.000	0.000	156.057	146.776	9.281	2.228
2000	Belgium	311.463	228.692	0.734	-0.309	280.9	5.638	2.700	2.664	5.280	5.145	1.000	0.000	185.552	178.745	6.807	1.918
2001	Belgium	313.991	236.729	0.754	-0.282	286.0	5.656	2.400	2.372	4.970	4.850	1.000	0.000	188.764	179.870	8.894	2.185
2002	Belgium	319.581	244.809	0.766	-0.267	288.0	5.663	1.500	1.489	4.460	4.363	1.000	0.000	193.411	178.270	15.141	2.717
2003	Belgium	322.056	251.893	0.782	-0.246	285.8	5.655	1.500	1.489	4.380	4.287	1.000	0.000	193.878	179.175	14.703	2.688
2004	Belgium	333.762	265.410	0.795	-0.229	288.3	5.664	1.900	1.882	3.660	3.595	1.000	0.000	210.203	196.157	14.046	2.642
2005	Belgium	340.752	277.882	0.815	-0.204	294.7	5.686	2.500	2.469	3.390	3.334	1.000	0.000	229.005	217.585	11.420	2.435
2006	Belgium	349.268	292.313	0.837	-0.178	297.4	5.695	2.300	2.274	3.820	3.749	1.000	0.000	247.320	235.140	12.180	2.500
2007	Belgium	361.135	309.462	0.857	-0.154	300.0	5.704	1.800	1.784	4.410	4.316	1.000	0.000	267.121	253.959	13.162	2.577
2008	Belgium	363.833	319.159	0.877	-0.131	327.6	5.792	4.500	4.402	3.870	3.797	1.000	0.000	282.176	280.463	1.713	0.538
2009	Belgium	355.519	315.373	0.887	-0.120	347.1	5.850	0.000	0.000	3.610	3.546	1.000	0.000	241.739	233.847	7.892	2.066
2010	Belgium	365.101	330.237	0.905	-0.100	364.1	5.897	2.300	2.274	3.990	3.912	1.000	0.000	279.114	272.554	6.560	1.881
2011	Belgium	371.661	343.579	0.924	-0.079	388.9	5.963	3.400	3.343	4.350	4.258	1.000	0.000	309.486	307.524	1.962	0.674
2012	Belgium	372.170	349.507	0.939	-0.063	404.3	6.002	2.600	2.567	2.100	2.078	1.000	0.000	318.935	316.546	2.389	0.871
2013	Belgium	371.920	353.686	0.951	-0.050	413.7	6.025	1.200	1.193	2.430	2.401	1.000	0.000	320.461	315.988	4.473	1.498
2014	Belgium	378.068	361.914	0.957	-0.044	427.5	6.058	0.500	0.499	0.910	0.906	1.000	0.000	333.478	329.805	3.673	1.301
2015	Belgium	383.740	370.853	0.966	-0.034	434.8	6.075	0.600	0.598	0.890	0.886	1.000	0.000	340.295	333.443	6.852	1.925
2016	Belgium	388.495	380.292	0.979	-0.021	446.8	6.102	1.800	1.784	0.610	0.608	1.000	0.000	356.035	343.150	12.885	2.556

Year	Country	GDP real	GDP Nominal	Deflator GDP	LOG_DEFLATOR_GDP	Government gross debt	LOG_GOVERNMENT_GROSS_DEBT	Inflation rate	LOG_INFLATION_RATE	Interest rate	LOG_INTEREST_RATE	Nominal Exchange Rate	LOG_NOMINAL_EXCHANGE_RATE	Exportations	Importations	Trade Balance	LOG_TRADE_BALANCE
1999	Finland	149.658	111.769	0.747	-0.292	55.9	4.024	1.300	1.292	5.370	5.231	1.000	0.000	47.726	36.343	11.383	10.780
2000	Finland	158.091	120.644	0.763	-0.270	57.9	4.059	3.000	2.956	5.140	5.012	1.000	0.000	57.348	44.840	12.508	11.785
2001	Finland	162.171	128.512	0.792	-0.233	59.2	4.081	2.700	2.664	4.980	4.860	1.000	0.000	57.360	44.130	13.230	12.425
2002	Finland	164.896	131.410	0.797	-0.227	59.7	4.089	2.000	1.980	4.450	4.354	1.000	0.000	57.960	44.790	13.170	12.372
2003	Finland	168.184	133.615	0.794	-0.230	64.9	4.173	1.300	1.292	4.330	4.239	1.000	0.000	56.484	46.640	9.844	9.389
2004	Finland	174.787	140.265	0.802	-0.220	67.7	4.215	0.100	0.100	3.680	3.614	1.000	0.000	61.155	51.350	9.805	9.354
2005	Finland	179.646	145.276	0.809	-0.212	65.8	4.187	0.800	0.797	3.300	3.247	1.000	0.000	66.175	59.791	6.384	6.189
2006	Finland	186.931	152.662	0.817	-0.203	65.9	4.188	1.300	1.292	3.820	3.749	1.000	0.000	74.519	67.340	7.179	6.933
2007	Finland	196.623	165.877	0.844	-0.170	63.4	4.149	1.600	1.587	4.340	4.248	1.000	0.000	82.091	73.102	8.989	8.608
2008	Finland	198.040	172.742	0.872	-0.137	63.3	4.148	3.900	3.826	3.720	3.652	1.000	0.000	87.321	80.262	7.059	6.821
2009	Finland	181.664	160.807	0.885	-0.122	75.5	4.324	1.600	1.587	3.460	3.401	1.000	0.000	65.661	62.021	3.640	3.575
2010	Finland	187.100	166.156	0.888	-0.119	88.2	4.480	1.700	1.686	3.190	3.140	1.000	0.000	72.366	69.998	2.368	2.340
2011	Finland	191.910	172.994	0.901	-0.104	95.5	4.559	3.300	3.247	2.520	2.489	1.000	0.000	77.093	78.768	-1.675	-1.689
2012	Finland	189.173	174.986	0.925	-0.078	107.7	4.679	3.200	3.150	1.600	1.587	1.000	0.000	78.881	81.764	-2.883	-2.925
2013	Finland	187.739	177.349	0.945	-0.057	114.8	4.743	2.200	2.176	2.030	2.010	1.000	0.000	78.924	80.724	-1.800	-1.816
2014	Finland	186.553	179.293	0.961	-0.040	123.7	4.818	1.200	1.193	0.890	0.886	1.000	0.000	76.482	78.393	-1.911	-1.929
2015	Finland	187.054	183.170	0.979	-0.021	133.4	4.893	-0.200	-0.200	0.860	0.856	1.000	0.000	77.186	77.810	-0.624	-0.626
2016	Finland	189.649	186.332	0.983	-0.018	136.1	4.913	0.400	0.399	0.460	0.459	1.000	0.000	75.677	78.262	-2.585	-2.619

Year	Country	GDP real	GDP Nominal	Deflator GDP	LOG_DEFLATOR_GDP	Government gross debt	LOG_GOVERNMENT_GROSS_DEBT	Inflation rate	LOG_INFLATION_RATE	Interest rate	LOG_INTEREST_RATE	Nominal Exchange Rate	LOG_NOMINAL_EXCHANGE_RATE	Exportations	Importations	Trade Balance	LOG_TRADE_BALANCE
1999	France	1705.606	1212.479	0.711	-0.341	847.5	6.742	0.600	0.598	5.270	5.136	1.000	0.000	362.177	331.102	31.075	27.060
2000	France	1771.701	1286.106	0.726	-0.320	870.4	6.769	1.800	1.784	5.040	4.917	1.000	0.000	418.461	402.308	16.153	14.974
2001	France	1806.328	1344.903	0.745	-0.295	897.3	6.799	1.800	1.784	4.870	4.755	1.000	0.000	429.317	409.674	19.643	17.934
2002	France	1826.531	1389.033	0.760	-0.274	956.8	6.864	1.900	1.882	4.380	4.287	1.000	0.000	431.084	404.555	26.529	23.530
2003	France	1841.500	1427.226	0.775	-0.255	1050.3	6.957	2.200	2.176	4.340	4.248	1.000	0.000	419.362	401.518	17.844	16.419
2004	France	1892.812	1485.377	0.785	-0.242	1123.5	7.024	2.300	2.274	3.640	3.575	1.000	0.000	443.241	432.613	10.628	10.100
2005	France	1923.243	1534.249	0.798	-0.226	1189.8	7.082	1.900	1.882	3.380	3.324	1.000	0.000	467.250	474.592	-7.342	-7.625
2006	France	1968.919	1606.337	0.816	-0.204	1193.3	7.084	1.900	1.882	3.810	3.739	1.000	0.000	503.641	519.126	-15.485	-16.824
2007	France	2015.415	1689.798	0.838	-0.176	1252.0	7.132	1.600	1.587	4.350	4.258	1.000	0.000	527.829	552.946	-25.117	-28.924
2008	France	2019.351	1738.723	0.861	-0.150	1357.3	7.213	3.200	3.150	3.540	3.479	1.000	0.000	546.588	581.543	-34.955	-43.009
2009	France	1959.955	1691.541	0.863	-0.147	1530.7	7.333	0.100	0.100	3.480	3.421	1.000	0.000	466.753	494.376	-27.623	-32.328
2010	France	1998.481	1748.676	0.875	-0.134	1631.7	7.397	1.700	1.686	3.340	3.285	1.000	0.000	520.469	558.080	-37.611	-47.178
2011	France	2040.034	1790.159	0.878	-0.131	1753.7	7.469	2.300	2.274	3.160	3.111	1.000	0.000	572.553	625.312	-52.759	-74.991
2012	France	2043.761	1810.360	0.886	-0.121	1868.4	7.533	2.200	2.176	2.010	1.990	1.000	0.000	595.230	640.240	-45.010	-59.802
2013	France	2055.538	1829.433	0.890	-0.117	1952.9	7.577	1.000	0.995	2.330	2.303	1.000	0.000	605.134	644.957	-39.823	-50.788
2014	France	2068.624	1857.047	0.898	-0.108	2038.0	7.620	0.600	0.598	0.920	0.916	1.000	0.000	619.459	661.983	-42.524	-55.380
2015	France	2094.982	1894.720	0.904	-0.100	2098.2	7.649	0.100	0.100	0.930	0.926	1.000	0.000	654.922	684.960	-30.038	-35.722
2016	France	2119.813	1933.825	0.912	-0.092	2147.4	7.672	0.300	0.300	0.750	0.747	1.000	0.000	655.967	694.308	-38.341	-48.355

Year	Country	GDP real	GDP Nominal	Deflator GDP	LOG_DEFLATOR_GDP	Government gross debt	LOG_GOVERNMENT_GROSS_DEBT	Inflation rate	LOG_INFLATION_RATE	Interest rate	LOG_INTEREST_RATE	Nominal Exchange Rate	LOG_NOMINAL_EXCHANGE_RATE	Exportations	Importations	Trade Balance	LOG_TRADE_BALANCE
1999	Germany	2290.835	1879.615	0.820	-0.198	1238.6	7.122	0.600	0.598	5.150	5.022	1.000	0.000	558.369	543.646	14.723	2.689
2000	Germany	2358.691	1925.352	0.816	-0.203	1245.8	7.128	1.400	1.390	4.890	4.774	1.000	0.000	652.501	646.806	5.695	1.740
2001	Germany	2398.682	1984.107	0.827	-0.190	1258.7	7.138	1.900	1.882	4.740	4.631	1.000	0.000	694.733	656.290	38.443	3.649
2002	Germany	2398.682	2010.446	0.838	-0.177	1312.4	7.180	1.400	1.390	4.330	4.239	1.000	0.000	719.655	622.997	96.658	4.571
2003	Germany	2381.653	2014.594	0.846	-0.167	1400.3	7.244	1.000	0.995	4.290	4.201	1.000	0.000	723.557	642.217	81.340	4.399
2004	Germany	2409.518	2065.200	0.857	-0.154	1470.6	7.293	1.800	1.784	3.580	3.517	1.000	0.000	804.899	690.443	114.456	4.740
2005	Germany	2426.546	2091.566	0.862	-0.149	1541.4	7.340	1.900	1.882	3.340	3.285	1.000	0.000	868.355	751.938	116.417	4.757
2006	Germany	2516.333	2176.151	0.865	-0.145	1591.3	7.372	1.800	1.784	3.770	3.701	1.000	0.000	985.788	858.981	126.807	4.843
2007	Germany	2598.378	2269.934	0.874	-0.135	1599.9	7.378	2.300	2.274	4.210	4.124	1.000	0.000	1080.938	913.826	167.112	5.119
2008	Germany	2626.501	2313.668	0.881	-0.127	1668.9	7.420	2.800	2.762	3.050	3.004	1.000	0.000	1113.329	960.269	153.060	5.031
2009	Germany	2478.922	2219.560	0.895	-0.111	1785.6	7.488	0.200	0.200	3.140	3.092	1.000	0.000	930.040	808.518	121.522	4.800
2010	Germany	2580.060	2333.590	0.904	-0.100	2088.8	7.644	1.100	1.094	2.910	2.868	1.000	0.000	1090.085	955.982	134.103	4.899
2011	Germany	2674.490	2436.456	0.911	-0.093	2128.3	7.663	2.500	2.469	1.930	1.912	1.000	0.000	1211.489	1079.344	132.145	4.884
2012	Germany	2687.649	2483.168	0.924	-0.079	2204.9	7.698	2.100	2.078	1.300	1.292	1.000	0.000	1268.318	1100.331	167.987	5.124
2013	Germany	2700.807	2547.422	0.943	-0.058	2189.8	7.692	1.600	1.587	1.800	1.784	1.000	0.000	1284.744	1116.353	168.391	5.126
2014	Germany	2743.894	2635.865	0.961	-0.040	2189.6	7.691	0.800	0.797	0.590	0.588	1.000	0.000	1334.833	1144.106	190.727	5.251
2015	Germany	2791.109	2732.136	0.979	-0.021	2158.8	7.677	0.100	0.100	0.550	0.548	1.000	0.000	1418.789	1189.250	229.539	5.436
2016	Germany	2842.968	2824.463	0.993	-0.007	2140.4	7.669	0.400	0.399	0.250	0.250	1.000	0.000	1441.387	1202.635	238.752	5.475

Year	Country	GDP real	GDP Nominal	Deflator GDP	LOG_DEFLATOR_GDP	Government gross debt	LOG_GOVERNMENT_GROSS_DEBT	Inflation rate	LOG_INFLATION_RATE	Interest rate	LOG_INTEREST_RATE	Nominal Exchange Rate	LOG_NOMINAL_EXCHANGE_RATE	Exportations	Importations	Trade Balance	LOG_TRADE_BALANCE
1999	Greece	182.738	119.147	0.652	-0.428	132.3	4.885	2.100	2.078	6.390	6.194	1.000	0.000	25.762	39.354	-13.592	-14.609
2000	Greece	189.901	125.396	0.660	-0.415	148.2	4.999	2.900	2.859	5.540	5.392	1.000	0.000	33.502	49.609	-16.107	-17.563
2001	Greece	197.747	134.877	0.682	-0.383	163.0	5.094	3.600	3.537	5.130	5.003	1.000	0.000	34.683	50.759	-16.075	-17.525
2002	Greece	205.505	145.280	0.707	-0.347	171.4	5.144	3.900	3.826	4.580	4.478	1.000	0.000	32.877	49.424	-16.548	-18.089
2003	Greece	217.413	160.186	0.737	-0.305	181.5	5.201	3.400	3.343	4.450	4.354	1.000	0.000	33.177	53.037	-19.860	-22.140
2004	Greece	228.416	174.234	0.763	-0.271	199.3	5.295	3.000	2.956	3.770	3.701	1.000	0.000	40.115	56.546	-16.431	-17.950
2005	Greece	229.785	178.720	0.778	-0.251	214.0	5.366	3.500	3.440	3.570	3.508	1.000	0.000	42.463	58.953	-16.490	-18.020
2006	Greece	242.773	193.950	0.799	-0.225	225.6	5.419	3.300	3.247	4.040	3.961	1.000	0.000	46.130	69.010	-22.880	-25.981
2007	Greece	250.721	206.754	0.825	-0.193	239.9	5.480	3.000	2.956	4.530	4.430	1.000	0.000	52.403	81.453	-29.049	-34.318
2008	Greece	249.880	214.769	0.859	-0.151	264.8	5.579	4.200	4.114	5.080	4.955	1.000	0.000	56.533	87.039	-30.507	-36.394
2009	Greece	239.134	213.239	0.892	-0.115	301.1	5.707	1.300	1.292	5.490	5.345	1.000	0.000	45.089	68.319	-23.230	-26.435
2010	Greece	226.032	200.660	0.888	-0.119	330.6	5.801	4.700	4.593	12.010	11.342	1.000	0.000	49.958	69.452	-19.495	-21.684
2011	Greece	205.389	183.377	0.893	-0.113	356.3	5.876	3.100	3.053	21.140	19.178	1.000	0.000	52.866	66.889	-14.024	-15.110
2012	Greece	190.395	169.619	0.891	-0.116	305.1	5.721	1.000	0.995	13.330	12.513	1.000	0.000	54.845	63.353	-8.508	-8.892
2013	Greece	184.223	159.797	0.867	-0.142	320.5	5.770	-0.900	-0.904	8.660	8.305	1.000	0.000	54.835	59.915	-5.081	-5.214
2014	Greece	184.873	154.532	0.836	-0.179	319.7	5.767	-1.400	-1.410	8.420	8.084	1.000	0.000	57.837	62.171	-4.333	-4.430
2015	Greece	184.468	151.586	0.822	-0.196	311.7	5.742	-1.100	-1.106	8.210	7.890	1.000	0.000	56.074	55.821	0.253	0.252
2016	Greece	184.490	150.102	0.814	-0.206	314.9	5.752	0.000	0.000	6.940	6.710	1.000	0.000	53.037	54.216	-1.180	-1.187

Year	Country	GDP real	GDP Nominal	Deflator GDP	LOG_DEFLATOR_GDP	Government gross debt	LOG_GOVERNMENT_GROSS_DEBT	Inflation rate	LOG_INFLATION_RATE	Interest rate	LOG_INTEREST_RATE	Nominal Exchange Rate	LOG_NOMINAL_EXCHANGE_RATE	Exportations	Importations	Trade Balance	LOG_TRADE_BALANCE
1999	Ireland	113.412	82.997	0.732	-0.312	43.2	3.766	2.400	2.372	5.390	5.250	1.000	0.000	80.402	68.118	12.283	2.508
2000	Ireland	124.654	96.863	0.777	-0.252	39.1	3.666	5.300	5.164	5.140	5.012	1.000	0.000	102.409	87.409	15.000	2.708
2001	Ireland	132.198	110.125	0.833	-0.183	40.5	3.701	4.000	3.922	4.930	4.812	1.000	0.000	116.255	97.203	19.052	2.947
2002	Ireland	139.570	122.936	0.881	-0.127	41.5	3.726	4.700	4.593	4.460	4.363	1.000	0.000	123.009	99.646	23.363	3.151
2003	Ireland	144.697	131.082	0.906	-0.099	43.6	3.775	4.000	3.922	4.360	4.268	1.000	0.000	117.685	95.630	22.055	3.094
2004	Ireland	154.427	139.601	0.904	-0.101	44.1	3.786	2.300	2.274	3.620	3.556	1.000	0.000	125.753	103.306	22.447	3.111
2005	Ireland	163.332	151.612	0.928	-0.074	44.4	3.793	2.200	2.176	3.360	3.305	1.000	0.000	135.441	116.911	18.531	2.919
2006	Ireland	172.913	163.178	0.944	-0.058	43.7	3.777	2.700	2.664	3.760	3.691	1.000	0.000	146.149	131.265	14.884	2.700
2007	Ireland	179.478	174.693	0.973	-0.027	47.1	3.852	2.900	2.859	4.450	4.354	1.000	0.000	159.305	142.994	16.311	2.792
2008	Ireland	171.629	168.624	0.982	-0.018	79.6	4.377	3.100	3.053	4.570	4.469	1.000	0.000	157.940	141.785	16.156	2.782
2009	Ireland	163.794	154.752	0.945	-0.057	104.7	4.651	-1.700	-1.715	4.880	4.765	1.000	0.000	158.596	135.674	22.922	3.132
2010	Ireland	167.124	152.154	0.910	-0.094	144.2	4.971	-1.600	-1.613	8.450	8.112	1.000	0.000	172.795	144.925	27.870	3.328
2011	Ireland	167.057	158.474	0.949	-0.053	189.7	5.245	1.200	1.193	8.700	8.342	1.000	0.000	177.303	145.143	32.160	3.471
2012	Ireland	165.214	160.719	0.973	-0.028	210.0	5.347	1.900	1.882	4.670	4.564	1.000	0.000	187.662	157.516	30.146	3.406
2013	Ireland	167.030	164.041	0.982	-0.018	215.3	5.372	0.500	0.499	3.480	3.421	1.000	0.000	191.183	157.314	33.869	3.523
2014	Ireland	181.164	174.860	0.965	-0.035	203.3	5.315	0.300	0.300	1.310	1.301	1.000	0.000	219.790	185.182	34.608	3.544
2015	Ireland	228.767	236.389	1.033	0.033	201.4	5.305	0.000	0.000	1.110	1.104	1.000	0.000	317.197	235.985	81.212	4.397
2016	Ireland	240.694	244.965	1.018	0.018	200.6	5.301	-0.200	-0.200	0.840	0.836	1.000	0.000	318.817	257.159	61.658	4.122

Year	Country	GDP real	GDP Nominal	Deflator GDP	LOG_DEFLATOR_GDP	Government gross debt	LOG_GOVERNMENT_GROSS_DEBT	Inflation rate	LOG_INFLATION_RATE	Interest rate	LOG_INTEREST_RATE	Nominal Exchange Rate	LOG_NOMINAL_EXCHANGE_RATE	Exportations	Importations	Trade Balance	LOG_TRADE_BALANCE
1999	Italy	1499.903	1019.595	0.680	-0.386	1285.1	7.159	1.600	1.587	5.360	5.221	1.000	0.000	272.473	251.662	20.811	18.905
2000	Italy	1555.551	1080.659	0.695	-0.364	1302.5	7.172	2.600	2.567	5.300	5.164	1.000	0.000	317.968	307.545	10.423	9.915
2001	Italy	1583.118	1140.434	0.720	-0.328	1360.3	7.215	2.300	2.274	5.050	4.927	1.000	0.000	334.227	317.923	16.305	15.104
2002	Italy	1587.053	1180.434	0.744	-0.296	1371.7	7.224	2.600	2.567	4.550	4.450	1.000	0.000	329.345	319.306	10.039	9.566
2003	Italy	1589.455	1222.815	0.769	-0.262	1397.5	7.242	2.800	2.762	4.460	4.363	1.000	0.000	324.880	318.582	6.298	6.107
2004	Italy	1614.599	1271.428	0.787	-0.239	1449.7	7.279	2.300	2.274	3.790	3.720	1.000	0.000	348.518	340.086	8.432	8.095
2005	Italy	1629.932	1303.103	0.799	-0.224	1518.6	7.326	2.200	2.176	3.550	3.488	1.000	0.000	367.242	368.888	-1.646	-1.660
2006	Italy	1662.638	1344.796	0.809	-0.212	1588.1	7.370	2.200	2.176	4.040	3.961	1.000	0.000	406.133	419.084	-12.951	-13.869
2007	Italy	1687.143	1399.472	0.829	-0.187	1606.2	7.382	2.000	1.980	4.540	4.440	1.000	0.000	441.455	447.237	-5.782	-5.956
2008	Italy	1669.421	1432.315	0.858	-0.153	1671.4	7.421	3.500	3.440	4.470	4.373	1.000	0.000	440.102	452.978	-12.876	-13.784
2009	Italy	1577.903	1388.091	0.880	-0.128	1770.2	7.479	0.800	0.797	4.010	3.932	1.000	0.000	353.530	363.846	-10.317	-10.889
2010	Italy	1604.515	1406.753	0.877	-0.132	1851.7	7.524	1.600	1.587	4.600	4.497	1.000	0.000	404.149	435.744	-31.596	-37.974
2011	Italy	1613.767	1432.941	0.888	-0.119	1907.9	7.554	2.900	2.859	6.810	6.588	1.000	0.000	442.219	467.932	-25.713	-29.723
2012	Italy	1568.274	1395.410	0.890	-0.117	1990.0	7.596	3.300	3.247	4.540	4.440	1.000	0.000	461.174	445.237	15.937	14.787
2013	Italy	1541.172	1395.675	0.906	-0.099	2070.2	7.635	1.200	1.193	4.110	4.028	1.000	0.000	463.129	426.888	36.241	30.926
2014	Italy	1542.924	1407.306	0.912	-0.092	2137.2	7.667	0.200	0.200	1.990	1.970	1.000	0.000	475.301	429.026	46.275	38.032
2015	Italy	1555.009	1426.240	0.917	-0.086	2172.9	7.684	0.100	0.100	1.580	1.568	1.000	0.000	493.934	446.042	47.893	39.132
2016	Italy	1568.691	1463.579	0.933	-0.069	2217.9	7.704	-0.100	-0.100	1.890	1.872	1.000	0.000	501.473	443.590	57.882	45.668

Year	Country	GDP real	GDP Nominal	Deflator GDP	LOG_DEFLATOR_GDP	Government gross debt	LOG_GOVERNMENT_GROSS_DEBT	Inflation rate	LOG_INFLATION_RATE	Interest rate	LOG_INTEREST_RATE	Nominal Exchange Rate	LOG_NOMINAL_EXCHANGE_RATE	Exportations	Importations	Trade Balance	LOG_TRADE_BALANCE
1999	Luxembourg	28.445	18.442	0.648	-0.433	1.4	0.344	1.000	0.995	5.260	5.126	1.000	0.000	27.305	22.621	4.684	1.544
2000	Luxembourg	30.789	20.281	0.659	-0.417	1.5	0.405	3.800	3.730	5.210	5.079	1.000	0.000	34.270	28.495	5.774	1.753
2001	Luxembourg	31.569	20.988	0.665	-0.408	1.6	0.495	2.400	2.372	4.510	4.411	1.000	0.000	35.049	29.455	5.595	1.722
2002	Luxembourg	32.774	22.296	0.680	-0.385	1.7	0.531	2.100	2.078	3.970	3.893	1.000	0.000	35.626	29.330	6.295	1.840
2003	Luxembourg	33.308	23.251	0.698	-0.359	1.8	0.582	2.500	2.469	3.290	3.237	1.000	0.000	36.375	30.169	6.206	1.826
2004	Luxembourg	34.512	24.585	0.712	-0.339	2.0	0.708	3.200	3.150	2.540	2.508	1.000	0.000	42.751	35.806	6.946	1.938
2005	Luxembourg	35.606	26.349	0.740	-0.301	2.2	0.798	3.800	3.730	2.740	2.703	1.000	0.000	48.553	40.871	7.682	2.039
2006	Luxembourg	37.450	29.905	0.799	-0.225	2.6	0.967	3.000	2.956	3.770	3.701	1.000	0.000	59.586	48.803	10.783	2.378
2007	Luxembourg	40.579	32.808	0.808	-0.213	2.9	1.054	2.700	2.664	4.680	4.574	1.000	0.000	67.996	55.626	12.370	2.515
2008	Luxembourg	40.060	33.875	0.846	-0.168	5.7	1.737	4.100	4.018	4.170	4.085	1.000	0.000	71.343	59.652	11.691	2.459
2009	Luxembourg	38.314	32.847	0.857	-0.154	5.8	1.761	0.000	0.000	3.800	3.730	1.000	0.000	60.667	48.773	11.894	2.476
2010	Luxembourg	40.178	35.754	0.890	-0.117	8.0	2.073	2.800	2.762	3.320	3.266	1.000	0.000	70.120	56.907	13.212	2.581
2011	Luxembourg	41.198	38.380	0.932	-0.071	8.1	2.088	3.700	3.633	2.270	2.245	1.000	0.000	76.829	62.787	14.041	2.642
2012	Luxembourg	41.053	39.056	0.951	-0.050	9.6	2.260	2.900	2.859	1.430	1.420	1.000	0.000	82.245	68.558	13.687	2.616
2013	Luxembourg	42.691	41.230	0.966	-0.035	10.9	2.388	1.700	1.686	2.100	2.078	1.000	0.000	89.441	74.286	15.155	2.718
2014	Luxembourg	45.093	44.128	0.979	-0.022	11.2	2.417	0.700	0.698	0.650	0.648	1.000	0.000	103.091	86.110	16.981	2.832
2015	Luxembourg	46.899	46.808	0.998	-0.002	11.3	2.426	0.100	0.100	0.270	0.270	1.000	0.000	118.871	100.710	18.161	2.899
2016	Luxembourg	48.859	48.530	0.993	-0.007	10.9	2.384	0.000	0.000	0.390	0.389	1.000	0.000	123.531	103.803	19.727	2.982

LISBON SCHOOL OF ECONOMICS & MANAGEMENT
UNIVERSIDADE DE LISBOA

Year	Country	GDP real	GDP Nominal	Deflator GDP	LOG_DEFLATOR_GDP	Government gross debt	LOG_GOVERNMENT_GROSS_DEBT	Inflation rate	LOG_INFLATION_RATE	Interest rate	LOG_INTEREST_RATE	Nominal Exchange Rate	LOG_NOMINAL_EXCHANGE_RATE	Exportations	Importations	Trade Balance	LOG_TRADE_BALANCE
1999	Netherlands	532.170	373.247	0.701	-0.355	242.9	5.493	2.000	1.980	5.280	5.145	1.000	0.000	249.900	227.729	22.171	3.099
2000	Netherlands	554.727	403.210	0.727	-0.319	232.1	5.447	2.300	2.274	5.030	4.908	1.000	0.000	297.929	268.653	29.276	3.377
2001	Netherlands	566.511	426.715	0.753	-0.283	234.5	5.457	5.100	4.974	4.890	4.774	1.000	0.000	304.244	272.494	31.750	3.458
2002	Netherlands	567.098	443.943	0.783	-0.245	240.1	5.481	3.900	3.826	4.360	4.268	1.000	0.000	300.413	266.831	33.582	3.514
2003	Netherlands	568.708	454.507	0.799	-0.224	251.8	5.529	2.200	2.176	4.330	4.239	1.000	0.000	302.530	268.259	34.271	3.534
2004	Netherlands	580.257	469.337	0.809	-0.212	261.3	5.566	1.400	1.390	3.630	3.566	1.000	0.000	332.889	291.375	41.514	3.726
2005	Netherlands	592.793	487.552	0.822	-0.195	268.9	5.594	1.500	1.489	3.350	3.295	1.000	0.000	363.466	316.111	47.355	3.858
2006	Netherlands	613.651	516.916	0.842	-0.172	259.7	5.560	1.600	1.587	3.820	3.749	1.000	0.000	401.272	350.695	50.577	3.923
2007	Netherlands	636.347	548.223	0.862	-0.149	262.1	5.569	1.600	1.587	4.340	4.248	1.000	0.000	430.974	376.850	54.124	3.991
2008	Netherlands	647.159	573.078	0.886	-0.122	350.5	5.859	2.200	2.176	3.650	3.585	1.000	0.000	457.913	402.775	55.138	4.010
2009	Netherlands	622.777	558.762	0.897	-0.108	351.1	5.861	1.000	0.995	3.440	3.382	1.000	0.000	390.004	344.748	45.256	3.812
2010	Netherlands	631.512	569.476	0.902	-0.103	374.7	5.926	0.900	0.896	3.160	3.111	1.000	0.000	454.398	401.585	52.813	3.967
2011	Netherlands	642.018	581.738	0.906	-0.099	396.3	5.982	2.500	2.469	2.380	2.352	1.000	0.000	497.347	442.443	54.904	4.006
2012	Netherlands	635.232	584.546	0.920	-0.083	428.3	6.060	2.800	2.762	1.560	1.548	1.000	0.000	528.623	466.677	61.946	4.126
2013	Netherlands	634.023	588.562	0.928	-0.074	442.2	6.092	2.600	2.567	2.160	2.137	1.000	0.000	535.320	465.502	69.818	4.246
2014	Netherlands	643.024	594.321	0.924	-0.079	450.5	6.110	0.300	0.300	0.780	0.777	1.000	0.000	547.415	475.530	71.885	4.275
2015	Netherlands	655.574	606.410	0.925	-0.078	441.0	6.089	0.200	0.200	0.750	0.747	1.000	0.000	557.890	484.963	72.927	4.289
2016	Netherlands	669.999	621.445	0.928	-0.075	434.1	6.073	0.100	0.100	0.440	0.439	1.000	0.000	561.977	486.274	75.703	4.327

Year	Country	GDP real	GDP Nominal	Deflator GDP	LOG_DEFLATOR_GDP	Government gross debt	LOG_GOVERNMENT_GROSS_DEBT	Inflation rate	LOG_INFLATION_RATE	Interest rate	LOG_INTEREST_RATE	Nominal Exchange Rate	LOG_NOMINAL_EXCHANGE_RATE	Exportations	Importations	Trade Balance	LOG_TRADE_BALANCE
1999	Portugal	161.046	105.545	0.655	-0.423	61.1	4.113	2.200	2.176	5.460	5.316	1.000	0.000	31.671	44.053	-12.382	-13.218
2000	Portugal	167.145	113.328	0.678	-0.389	64.6	4.168	2.800	2.762	5.280	5.145	1.000	0.000	36.216	50.401	-14.185	-15.297
2001	Portugal	170.393	120.028	0.704	-0.350	72.6	4.285	4.400	4.306	5.010	4.889	1.000	0.000	37.249	51.126	-13.876	-14.938
2002	Portugal	171.703	125.381	0.730	-0.314	80.1	4.383	3.700	3.633	4.450	4.354	1.000	0.000	38.433	50.228	-11.796	-12.551
2003	Portugal	170.099	127.861	0.752	-0.285	85.7	4.451	3.200	3.150	4.400	4.306	1.000	0.000	39.100	49.236	-10.136	-10.687
2004	Portugal	173.181	134.025	0.774	-0.256	94.5	4.549	2.500	2.469	3.640	3.575	1.000	0.000	41.528	54.105	-12.577	-13.441
2005	Portugal	174.509	138.472	0.793	-0.231	106.9	4.672	2.100	2.078	3.460	3.401	1.000	0.000	42.415	56.857	-14.443	-15.598
2006	Portugal	177.219	144.221	0.814	-0.206	115.0	4.745	3.000	2.956	3.960	3.884	1.000	0.000	49.737	63.434	-13.697	-14.731
2007	Portugal	181.635	152.733	0.841	-0.173	120.1	4.788	2.400	2.372	4.470	4.373	1.000	0.000	54.405	67.814	-13.409	-14.397
2008	Portugal	181.997	156.274	0.859	-0.152	128.2	4.854	2.700	2.664	4.000	3.922	1.000	0.000	55.675	73.048	-17.374	-19.084
2009	Portugal	176.577	155.875	0.883	-0.125	146.7	4.988	-0.900	-0.904	3.910	3.835	1.000	0.000	47.513	59.655	-12.143	-12.945
2010	Portugal	179.930	159.102	0.884	-0.123	173.1	5.154	1.400	1.390	6.530	6.326	1.000	0.000	53.751	67.351	-13.600	-14.618
2011	Portugal	176.643	154.848	0.877	-0.132	196.2	5.279	3.600	3.537	13.080	12.293	1.000	0.000	60.410	67.952	-7.542	-7.842
2012	Portugal	169.527	147.939	0.873	-0.136	212.6	5.359	2.800	2.762	7.250	6.999	1.000	0.000	63.504	64.359	-0.855	-0.859
2013	Portugal	167.611	149.734	0.893	-0.113	219.7	5.392	0.400	0.399	6.040	5.865	1.000	0.000	67.284	65.573	1.711	1.697
2014	Portugal	169.108	151.226	0.894	-0.112	226.0	5.421	-0.200	-0.200	2.810	2.771	1.000	0.000	69.360	69.033	0.327	0.327
2015	Portugal	171.805	155.415	0.905	-0.100	231.5	5.445	0.500	0.499	2.490	2.460	1.000	0.000	72.808	71.503	1.306	1.297
2016	Portugal	174.217	160.155	0.919	-0.084	241.1	5.485	0.600	0.598	3.740	3.672	1.000	0.000	74.473	72.262	2.211	2.187

Year	Country	GDP real	GDP Nominal	Deflator GDP	LOG_DEFLATOR_GDP	Government gross debt	LOG_GOVERNMENT_GROSS_DEBT	Inflation rate	LOG_INFLATION_RATE	Interest rate	LOG_INTEREST_RATE	Nominal Exchange Rate	LOG_NOMINAL_EXCHANGE_RATE	Exportations	Importations	Trade Balance	LOG_TRADE_BALANCE
1999	Spain	824.319	537.213	0.652	-0.428	362.2	5.892	2.200	2.176	5.370	5.231	1.000	0.000	156.883	168.434	-11.551	-12.274
2000	Spain	867.918	584.097	0.673	-0.396	374.6	5.926	3.500	3.440	5.200	5.069	1.000	0.000	184.932	204.355	-19.423	-21.596
2001	Spain	902.644	634.007	0.702	-0.353	378.9	5.937	2.800	2.762	4.970	4.850	1.000	0.000	194.904	211.341	-16.437	-17.957
2002	Spain	928.638	679.765	0.732	-0.312	384.1	5.951	3.600	3.537	4.430	4.335	1.000	0.000	198.390	213.590	-15.200	-16.487
2003	Spain	958.239	725.603	0.757	-0.278	382.8	5.948	3.100	3.053	4.340	4.248	1.000	0.000	204.462	222.273	-17.811	-19.615
2004	Spain	988.584	773.453	0.782	-0.245	389.9	5.966	3.100	3.053	3.640	3.575	1.000	0.000	216.896	250.101	-33.205	-40.354
2005	Spain	1025.390	830.922	0.810	-0.210	393.5	5.975	3.400	3.343	3.370	3.314	1.000	0.000	229.550	276.074	-46.524	-62.594
2006	Spain	1068.191	898.632	0.841	-0.173	392.1	5.972	3.600	3.537	3.820	3.749	1.000	0.000	250.703	310.328	-59.625	-90.696
2007	Spain	1108.450	972.726	0.878	-0.131	384.7	5.952	2.800	2.762	4.350	4.258	1.000	0.000	277.851	342.602	-64.751	-104.273
2008	Spain	1120.820	1024.959	0.914	-0.089	440.6	6.088	4.100	4.018	3.860	3.787	1.000	0.000	282.589	339.795	-57.206	-84.877
2009	Spain	1080.764	1004.347	0.929	-0.073	569.5	6.345	-0.200	-0.200	3.810	3.739	1.000	0.000	244.658	257.071	-12.413	-13.254
2010	Spain	1080.913	987.354	0.913	-0.091	650.1	6.477	2.000	1.980	5.380	5.240	1.000	0.000	275.847	289.953	-14.106	-15.206
2011	Spain	1070.103	980.383	0.916	-0.088	744.3	6.612	3.000	2.956	5.530	5.383	1.000	0.000	309.575	312.207	-2.632	-2.667
2012	Spain	1038.751	945.512	0.910	-0.094	891.5	6.793	2.400	2.372	5.340	5.202	1.000	0.000	319.223	303.950	15.273	14.213
2013	Spain	1021.031	925.708	0.907	-0.098	979.0	6.887	1.500	1.489	4.130	4.047	1.000	0.000	330.453	297.062	33.391	28.811
2014	Spain	1035.111	932.777	0.901	-0.104	1041.6	6.949	-0.200	-0.200	1.780	1.764	1.000	0.000	338.769	313.698	25.071	22.371
2015	Spain	1068.283	963.359	0.902	-0.103	1073.9	6.979	-0.600	-0.602	1.690	1.676	1.000	0.000	356.873	330.527	26.346	23.385
2016	Spain	1102.850	999.130	0.906	-0.099	1107.0	7.009	-0.300	-0.300	1.440	1.430	1.000	0.000	368.322	335.908	32.414	28.076

A.2 Graphics

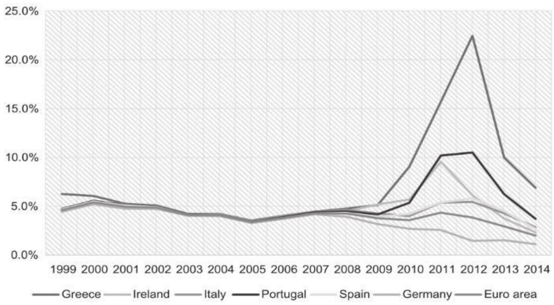

Fig. A.1. Sovereign Bond Yields – Approximate Yield for 10-Year Sovereign Bond (Yearly Moving Average). *Source:* adapted from Eurostat & Cardão-Pito (2017).

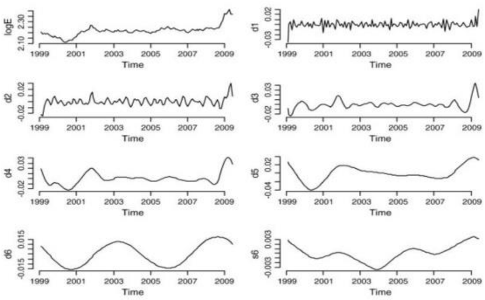

Fig. A.2. Time series plots of data for the monthly spot exchange rate (SEK/EUR in log scale). *Source:* "An investigation of the causal relations between exchange rates and interest rate differentials using wavelets".

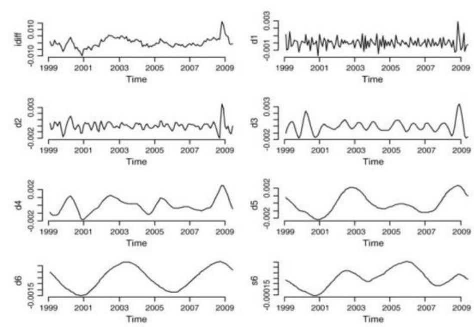

Fig. A.3. Time series plots of data for the monthly nominal interest differential between Sweden and the euro zone. *Source:* "An investigation of the causal relations between exchange rates and interest rate differentials using wavelets".

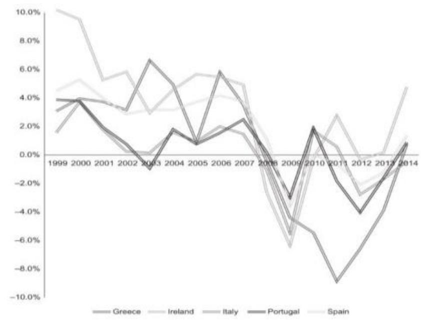

Fig. A.4. Annual GDP Variation. *Source:* World Bank and Cardão-Pito (2017).

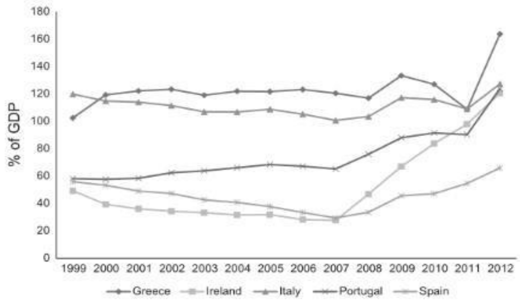

Fig. A.5. Central Government Debt (as a Percentage of GDP). *Source:* World Bank and Cardão-Pito (2017)